NAVIGATION STUDY FOR

JACKSONVILLE HARBOR, FLORIDA

DRAFT INTEGRATED GENERAL REEVALUATION REPORT II

AND

SUPPLEMENTAL ENVIRONMENTAL IMPACT STATEMENT

APPENDIX A

ATTACHMENT F

ADCIRC Boundary Conditions for Project Design and Impact Analysis

TO BE INCLUDED.

NAVIGATION STUDY FOR Jacksonville Harbor, FLORIDA
DRAFT FEASIBILITY STUDY REPORT

APPENDIX A
ATTACHMENT G

ENGINEERING – AdH Hydrodynamic Modeling for Ship Simulation, (Riverine) Channel Shoaling and Bank Impacts

March 2013

EXECUTIVE SUMMARY

Using the Adaptive Hydraulics (AdH) software, a high-resolution finite element model for Jacksonville Harbor was developed to primarily simulate the pre- and post-dredging hydrodynamics for input to ship simulation. Results from the hydrodynamic modeling and ship simulation studies were used to evaluate the effects of project dredging alternatives designed to accommodate navigation improvements in the federal channel of the Jacksonville Harbor project. The hydrodynamic modeling provided the necessary information of the time-varying currents due to tidal variations. The model was applied to simulate the water levels and the currents for the existing conditions and for seven different alternatives. The simulations focused on the investigation of the tidal currents and water levels for the pre- and post-drainage conditions.

To represent the project features including different extents of widening and deepening, the finite element mesh for the numerical model was generated using an irregular network of triangles. The triangles varied in size with higher resolutions in the federal channel and in the areas where widening and deepening of the channel were considered under different alternatives. The quality of mesh was maintained using the options available for checking and refining in the model's graphical user interface.

The data required for the model were organized and integrated to develop a conceptual basis of the model. All the conceptual model data were translated into the numerical model and test runs were performed initially. Subsequently, calibration and validation of the model were performed. Model calibration was accomplished by comparing with the measured data for the water levels and the currents for the period from June 16, 2009 at 3:00 pm to June 19, 2009 at 3:00 pm.

A reasonable agreement of surface elevations and current velocities with observed data was obtained at different locations within the model domain. The calibrated model was later run and validated to gain confidence in the predictive simulations. The validation was done by demonstrating the model's ability to reproduce a different set of observed data for the period from June 26, 2009 at 12:00 am to June 29, 2009 at 12:00 am. After the successful calibration and validation of the model, seven alternatives based on different extents of widening and deepening were simulated. Tidal simulations were performed for simulating the water levels and current velocities for the pre- and post-dredging conditions. The velocities generated by the model were used for ship simulation.

The sediment transport processes were later included in the model to simulate the effects of dredging on the shoaling or sedimentation rates within the federal channel. The AdH sediment transport model for Jacksonville Harbor was later run for three months from May 1 through July 31, 2009 for both existing condition and for with-project (46-ft depth) condition. The observed bed levels were compared with the model results. A reasonable agreement was obtained between the observed data and the model results. Compared to the existing condition, some decrease in the shoaling occurs in the channel from Mayport to Mile Point due to the project. However, the

shoaling increases in the Mill Cove to Bartram Island deepening reaches primarily because of construction of new turning basins at Mill Cove and near Bartram Island. Ninety six percent of the shoaling in Section 2 occurs within the Mill Cover turning basin. Eighty one percent of the shoaling in Section 3A occurs within the turning basin near Bartram Island. Overall, the model results show a fifteen percent increase in the shoaling volume due to the project condition within the Mayport to Bartram Island reaches (Dredging Sections 1, 2, 3A)..

The tidal variations and currents for the existing and with-project conditions were investigated at the north bank of Cut-41 and at the north bank of Mile Point. At the north bank of Cut-41, the water levels do not change significantly compared to the existing condition. The currents for with-project condition show an overall decrease. At the north bank in the Mile Point area, the tides and currents for with–project condition do not show any significant variations compared to the existing condition.

The hydrodynamic model for Jacksonville Harbor was applied to study the effects of the beneficial use of dredged materials by creating islands in the Mill Cove area. The model results for water surface elevations, currents, and flows were analyzed to investigate the effects of the islands. The overall effects on water levels and flow volumes are not significant. In the immediate vicinity of the islands, slight decrease in currents is observed. This could cause increased sedimentation in Mill Cove, which currently experiences shoaling.

1.0 INTRODUCTION

1.1 Background

The Jacksonville Harbor is located at the confluence of the St. Johns River with the Atlantic Ocean. The harbor provides navigation for vessels through the federal navigation channel that extends from the Atlantic Ocean to the terminals on the west along St. Johns River. The vessels currently using the Jacksonville Harbor must carry light load or wait for a favorable tidal condition while entering or leaving the harbor (USACE-SAJ, 2007). The problems are mainly related to the navigation including insufficient depth, difficult currents, and inadequate turning basins.

The present 40-ft depth of Jacksonville Harbor impacts the introduction of larger vessels for using the existing terminals (USACE-SAJ, 2007). There are certain areas having difficult currents and inadequate turning basins for larger vessels. In particular, the difficult currents at a few locations entailed investigation. For the improvement of the channel, hydrodynamic modeling studies have been performed.

1.2 Site Description

Jacksonville Harbor is located in Duval County, FL. The harbor extends from the mouth of the Atlantic Ocean toward the west. This harbor provides access to deep draft vessels for using the terminal facilities in the city of Jacksonville, FL. The main shipping channel is a 21-mile long segment of the St. Johns River from the mouth of the Atlantic Ocean to the Jacksonville Port Authority's Talleyrand Marine Terminal, which is located just north of downtown Jacksonville. There are other downstream terminals including the Interim Cruise Ship Terminal and Oil Terminals. These terminal facilities are used by different deep draft vessels.

The Jacksonville Harbor includes the Lower St. Johns River that is joined near the mouth by the Atlantic Intracoastal Waterway. There are a number of tributary watersheds that contribute freshwater flow to the St. Johns River. The hydrology of Jacksonville Harbor varies under the influence of rainfall, tide, wind, and freshwater flows. There exist wetlands with marsh areas that have effects on the tidal fluctuations in the harbor. The tidal signal is influenced by the hydraulics of the marsh areas because these areas tend to store and then release water during the incoming and receding phases of the flood tide.

The St. Johns River widens from Palatka to Jacksonville, narrows near downtown, and turns eastward to the Atlantic Ocean with a depth of about 30 ft. The segment of the river from the Talleyrand Terminal to the mouth has a federally designated depth and width to maintain navigation. At the present, the general navigation features include main channel having a depth of 40-ft MLW (Mean Low Water) to river mile 14.7 and 38 ft MLW to river mile 20 as shown in Figure 1 (USACE-SAJ, 2007).

Figure 1. Existing Jacksonville Harbor Project Features.

1.3 Objectives

Hydrodynamic models are widely used as tools for the investigation of the dredging in a system under the influence of tides and freshwater inflows. The primary objective of this study was to investigate and analyze the effects of making navigation improvements (primarily through dredging) to the federal channel. For the present study, a hydrodynamic model was developed first for simulating the processes associated with the currents in the federal channel extending from its confluence with the Atlantic Ocean upstream to the Talleyrand Terminal. The aims for the modeling analysis were to develop simulations for the regimes of the current and depth for the existing condition and for different alternatives. Using the hydrodynamic model, the impacts of the deepening and widening measures on the currents and on the depths of flows were investigated. To achieve the objectives for the development of a hydrodynamic model, the following main tasks were completed:

- Identify the model domain and divide it into sub-domains based on the hydraulic characteristics;
- Select a modeling code and discretize the domain to obtain a mesh for representing the hydrodynamic system;

- Calibrate the hydrodynamic model by comparing with the observed data;
- Validate the hydrodynamic model by running the calibrated model with a new dataset and compare the results with the observed data;
- Perform model runs to simulate the impacts of widening and deepening of the channel through ship simulation;
- Include sediment transport processes to simulate the effects on the shoaling; and
- Simulate the effects of creating disposal islands as a beneficial use of dredged material in Mill Cove.

2.0 CONCEPTUAL MODEL

The conceptual model was developed using the existing hydrologic, hydraulic, and hydrodynamic data. The physically based data for the conceptual model includes bathymetry, boundary conditions, flow parameters, estimated eddy viscosity coefficient, and Manning roughness coefficient. These data were analyzed and incorporated to develop a conceptual model for the site. Once the conceptual model was developed, the data incorporated were translated to the discretized mesh for developing a numerical model.

The description of the geometries and the hydrodynamic processes is required for developing a physically based numerical model for a system that exists in Jacksonville Harbor. The bathymetry obtained through the hydrographic surveys obtained for reaches of the Jacksonville Harbor that were either regularly maintenance dredged or that were being considered for improvement was assigned in the model domain. The hydraulically important navigation channels such as Intracoastal Waterway was represented in the model by using detailed bathymetry. The major creeks and rivers tributary to the St, Johns River are included in the model. The storage volumes in these areas have effects on the flows and tides (generated from the Atlantic Ocean) in the St. Johns River.

The tidal data collected for different locations in the project area were analyzed. In the Jacksonville Harbor, the influence of the semi-diurnal tide causes the sea levels to fluctuate twice daily. A typical tidal fluctuation observed in an offshore location on the north side of the mouth of the St. Johns River is shown in Figure 2. For this study, variable roughness values were used in the model. In the federal navigation channel, a roughness value of 0.025 was used. In the marsh areas, a relatively high value (0.045) of the roughness coefficient was used.

The spatially varying data necessary for the model were organized using the Surface water Modeling System (SMS) obtained from USACE Engineering Research and Development Center (ERDC). Here the map module of SMS was used to describe the model boundary including various project features. The data on the geometry, bathymetry, and material properties were integrated into the map module and finally translated into the mesh for generating the numerical model input files.

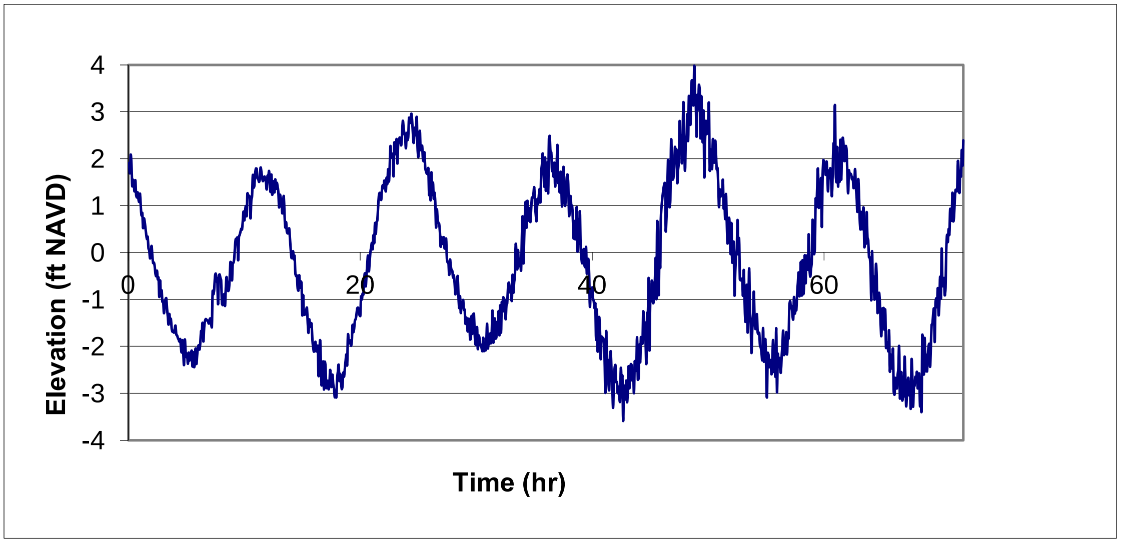

Figure 2. A typical tidal fluctuation in the ocean near Jacksonville Harbor.

3.0 NUMERICAL MODEL FOR HYDRODYNAMIC SIMULATION

3.1 Model Selection

In the present study, the focus was primarily to develop a hydrodynamic model as a predictive tool for simulating the water levels and the currents in the Jacksonville Harbor. For this, a conceptualization of the hydrodynamic system was needed while selecting an appropriate numerical model for a realistic representation of the harbor including offshore areas in the Atlantic Ocean. The requirements for the capability of the model included (but not limited to):

- the ability to simulate the time-varying currents and depths of flows,
- the ability to simulate sediment transport processes,
- the ability to simulate wetting and drying events without instability,
- the ability to allow the variation of various solution-specific parameters to ensure convergence of the model runs,
- the ability to have Neumann (flux) and Dirichlet (specified water level) type boundary conditions,
- the ability to represent the domain having irregular boundaries, and
- the ability to represent various project features.

Previous Jacksonville Harbor modeling and initial attempts for the present modeling effort involved using RMA2, a two-dimensional hydrodynamic model. There exist shortcomings in the model in terms of its convergence for a complex domain such as the one under Jacksonville Harbor (having wetland areas with wetting and drying processes). Through communications and consultations with ERDC, it was decided to select Adaptive Hydraulics (AdH) for the present modeling analysis because it met the aforementioned criteria and it was proven to be an efficient and robust numerical model for hydrodynamic simulation. The AdH is a software package (developed by ERDC) that includes two-dimensional shallow water module (Berger and Tate, 2007). This module is based on the solution of the two-dimensional form of the Navier-Stoke's equation using finite element method.

3.2 Model Domain

The model domain was selected to adequately represent the currents and depths associated with the widening and deepening of the federal channel. The extent of the model domain initially used in the RMA2 model for Jacksonville Harbor was maintained in the present AdH model. The long segment of the St. Johns River south of the Talleyrand Terminal was modeled by including the entire width of the river, which can reach several miles. To adequately represent the hydrodynamic behavior, the creeks and rivers joining the channel were included in the domain. The hydrodynamics of the main channel is influenced by the storage volume in the adjacent wetland areas. Thus, the marsh areas (and particularly the vast expanse of tidal marshes and coves adjacent to the downstream reaches of the channel) were included in the model domain.

The extents of the model domain were determined based on the maps showing various project features and based on the site-specific hydrographic data. Figure 3 shows the plan view of the model domain. The bathymetry within the model domain were examined and improved by adding the latest data. The two-dimensional variations of the existing bottom elevations i.e. bathymetry are shown in Figure 4.

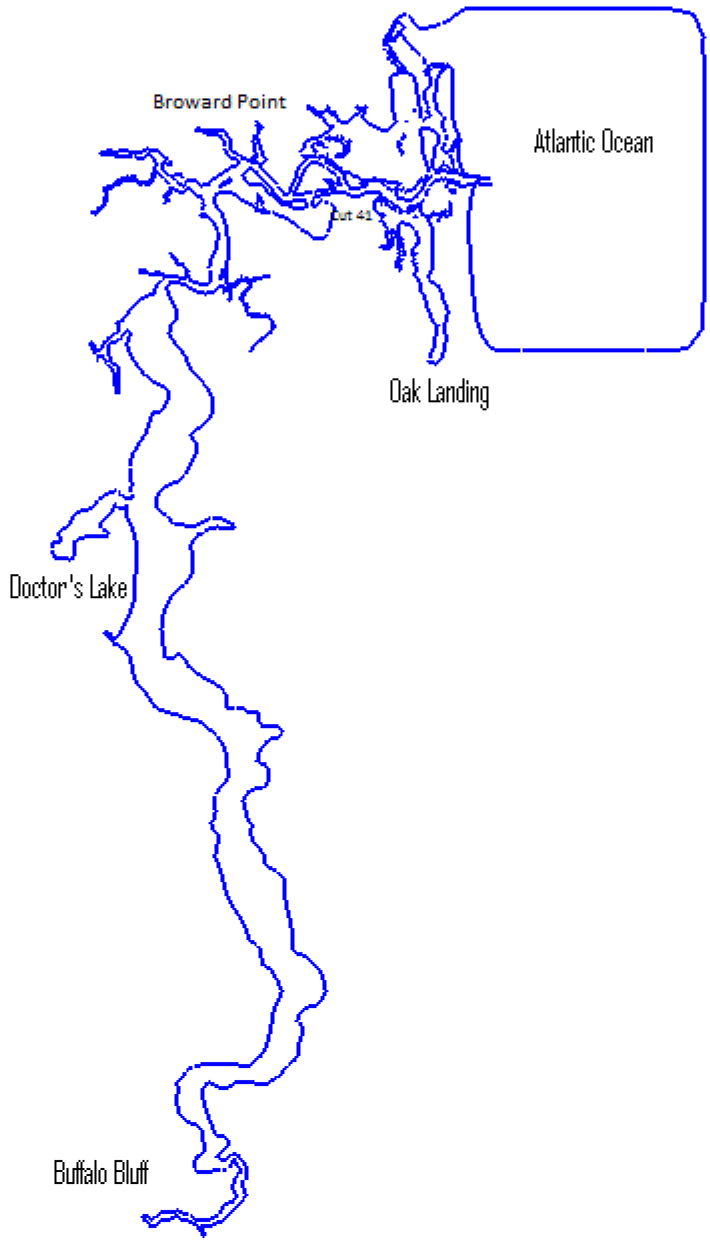

Figure 3. Model domain.

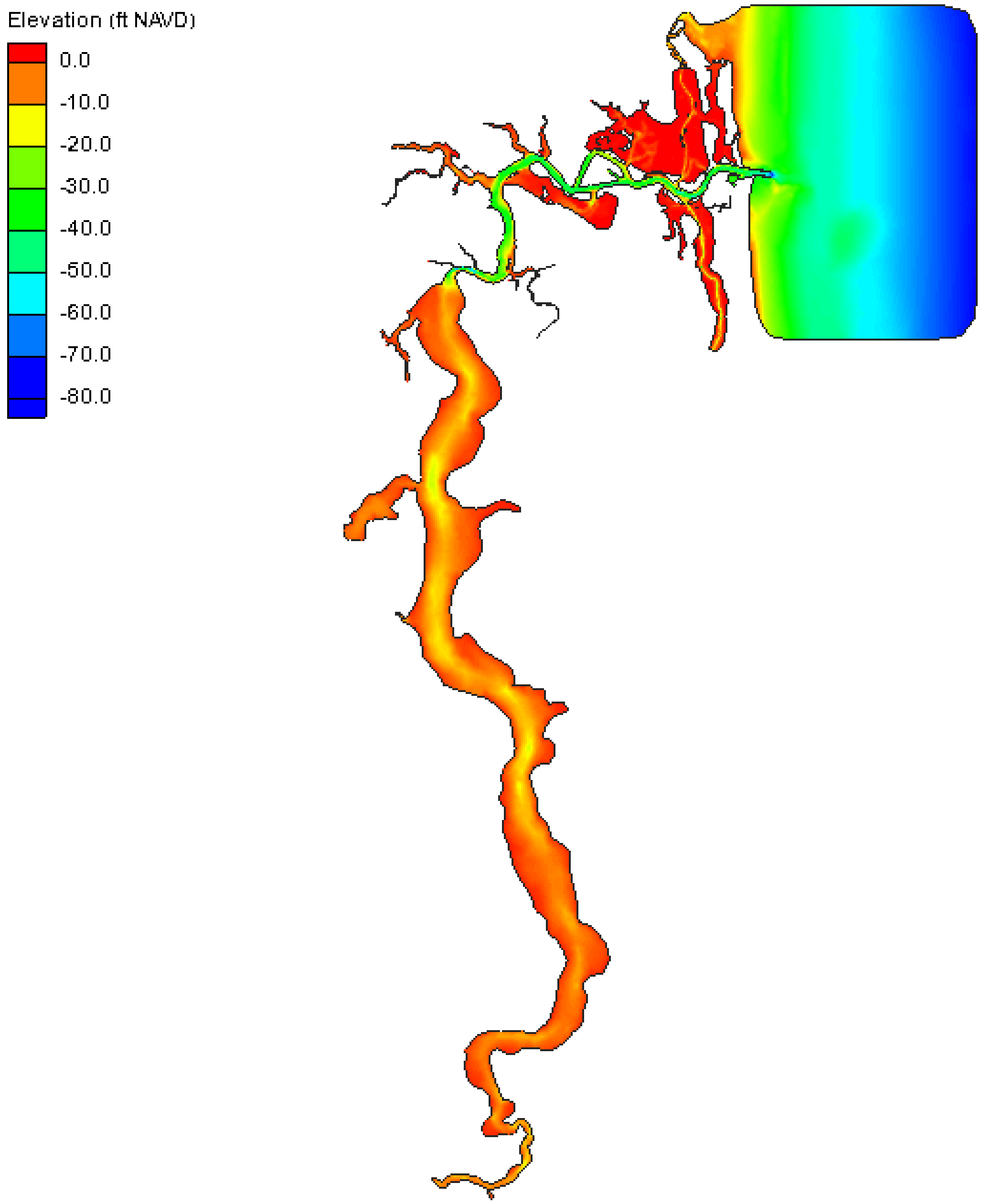

Figure 4. Existing bathymetry for the Jacksonville Harbor model domain.

3.3 Boundary and Initial Conditions

Physically meaningful boundary conditions were assigned at the southern end, at the Oak Landing, and on the north and south sides in the ocean as shown in Figure 5. Two types of boundary conditions have been employed for the Jacksonville Harbor AdH model. These are: (1)

total discharge and (2) time-varying water surface elevation. The former boundary condition data indicates natural (i.e. flux through a cross section) condition and the latter boundary condition data indicates Dirichlet (i.e. specified water levels) condition.

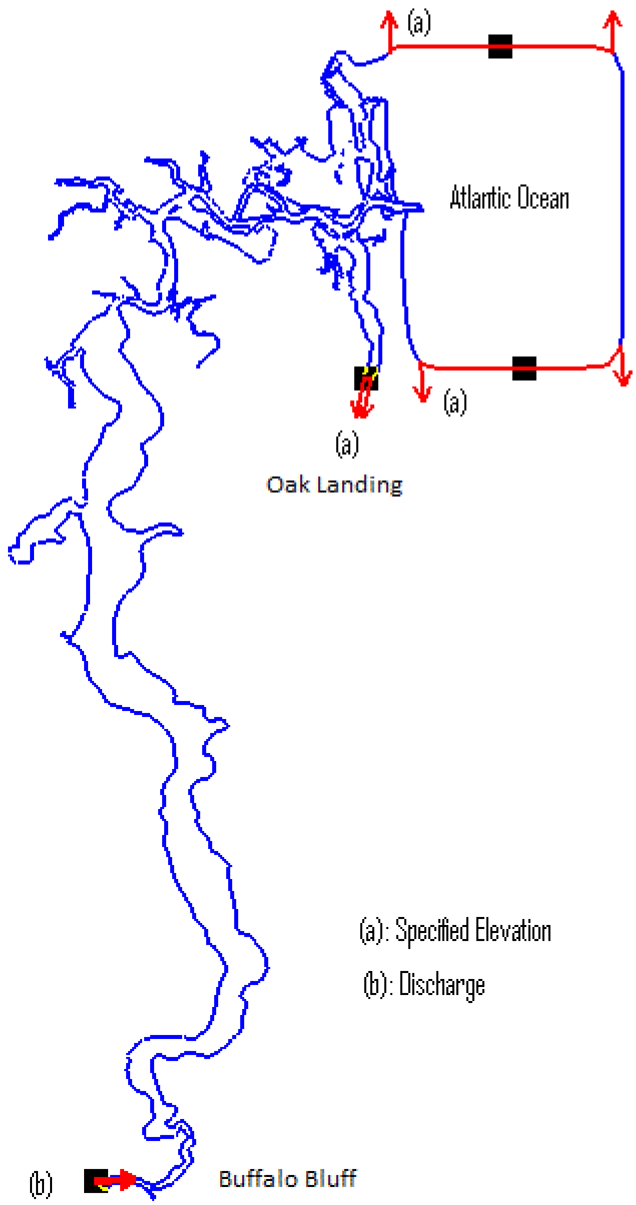

Figure 5. Boundary conditions assigned in the model.

At the southern boundary, a reasonable freshwater steady inflow of 23,560 cfs at Buffalo Bluff was used for the 3-day AdH hydrodynamic simulation based on the flow value used in the prior RMA2 modeling. In the present AdH sediment transport model 3-month simulation, the time-varying flow data from USGS station 2244040 at Buffalo Bluff has been used. During the 3-

month simulation, the upstream boundary inflows varied from a high of +25,100 cfs (positive flow direction is toward north) to a low of -33,300 cfs (negative flow direction is toward south), with an average flow of +5,730 cfs. At the other locations, the tidal data were assigned as the time-varying specified water levels. The specified water levels at the northern side in the ocean, at the southern side in the ocean, and at Oak Landing are shown in the Figures 6, 7, and 8, respectively.

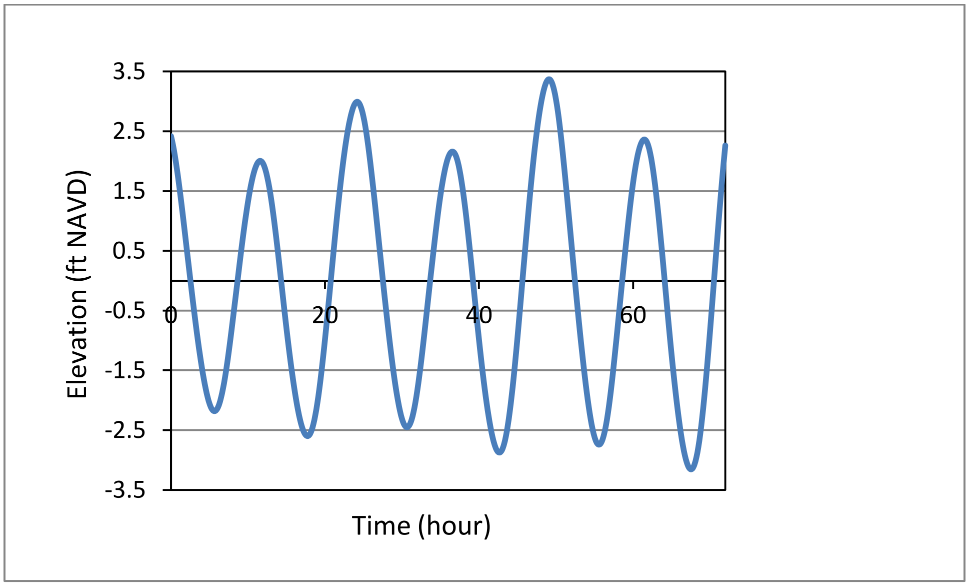

Figure 6. Specified water levels at the ocean side boundary (north).

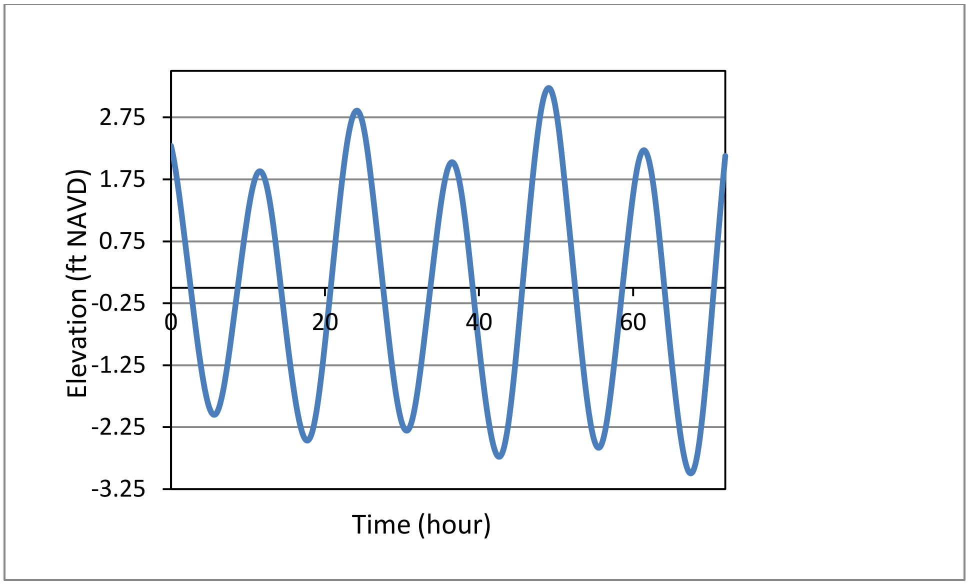

Figure 7. Specified water levels at the ocean side boundary (south).

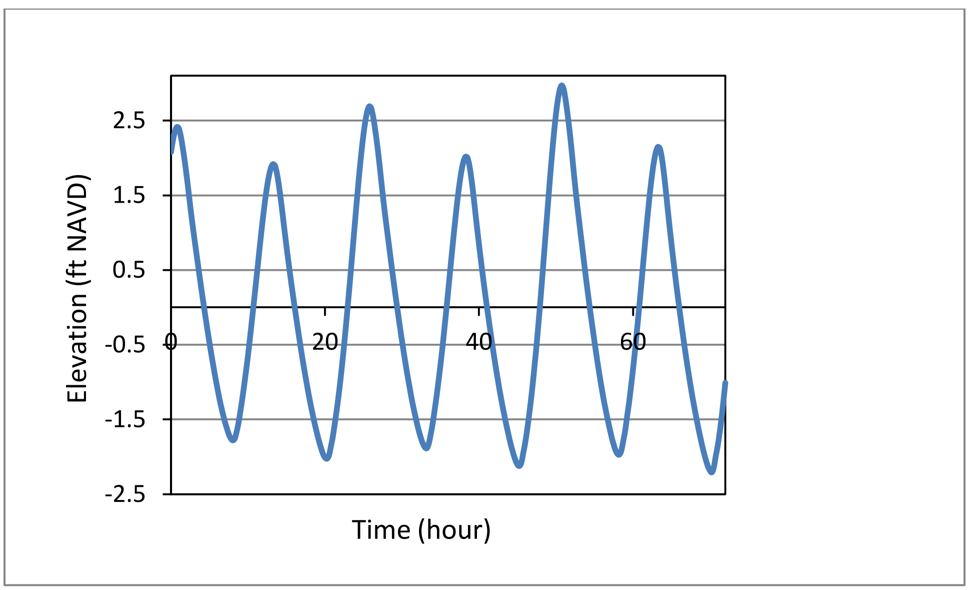

Figure 8. Specified water levels at Oak Landing.

The initial stage boundary condition in the Atlantic Ocean and at the southern boundary of the Intracoastal Waterway is defined by the initial depths based on a stationary water surface elevation of 2.34 ft NAVD. This elevation was chosen through some investigation so that the computations in the model domain start with a wet condition in most of the model domain. It is important to note that the compatibility of the boundary and initial conditions are ensured by the model at the onset of the simulation.

3.4 Finite Element Mesh Generation

The finite element mesh for modeling the domain under Jacksonville Harbor was generated using the SMS. The map module of SMS is used to organize the data. A number of input files were loaded into the map module for generating the mesh. These files include: site map showing the channels and wetlands, bathymetry, and alternatives showing different extents of widening and deepening. The high resolution of the finite element mesh for the model domain provided the ability to adequately represent the hydrodynamics of the alternatives.

The graphical user interface (GUI) within SMS allows the users to specify the mesh resolution along the boundaries of the polygons and along specified arcs inside the polygons. The map module in the interface distributes nodes throughout the interior of the polygons that describe the material properties. The process is repeated until the entire domain is covered by the desired distribution of elements and nodes. The mesh quality criteria included in SMS are followed while generating the triangular mesh for the model domain. These criteria are: minimum interior angle 10 degrees, maximum interior angle 130 degrees, and maximum 8 numbers of connecting elements at a node.

It is useful to develop a mesh that does not require an exorbitant amount of computer resources but provides a reasonable representation of the water body including the project features associated with the proposed alternatives. While generating the mesh, an attempt was made to represent the federal channel by at least two or more nodes across a cross section. A variable finite element mesh size was used, which offered advantages in terms of using fewer elements and nodes resulting in the increase in computational efficiency. The map module of SMS is found to be very useful in generating a feasible mesh with variable sizes that allows generating an optimal number of nodes while representing various project features. Figure 9 shows a triangular mesh that is used in the federal channel and in the areas depicting different limits of widening.

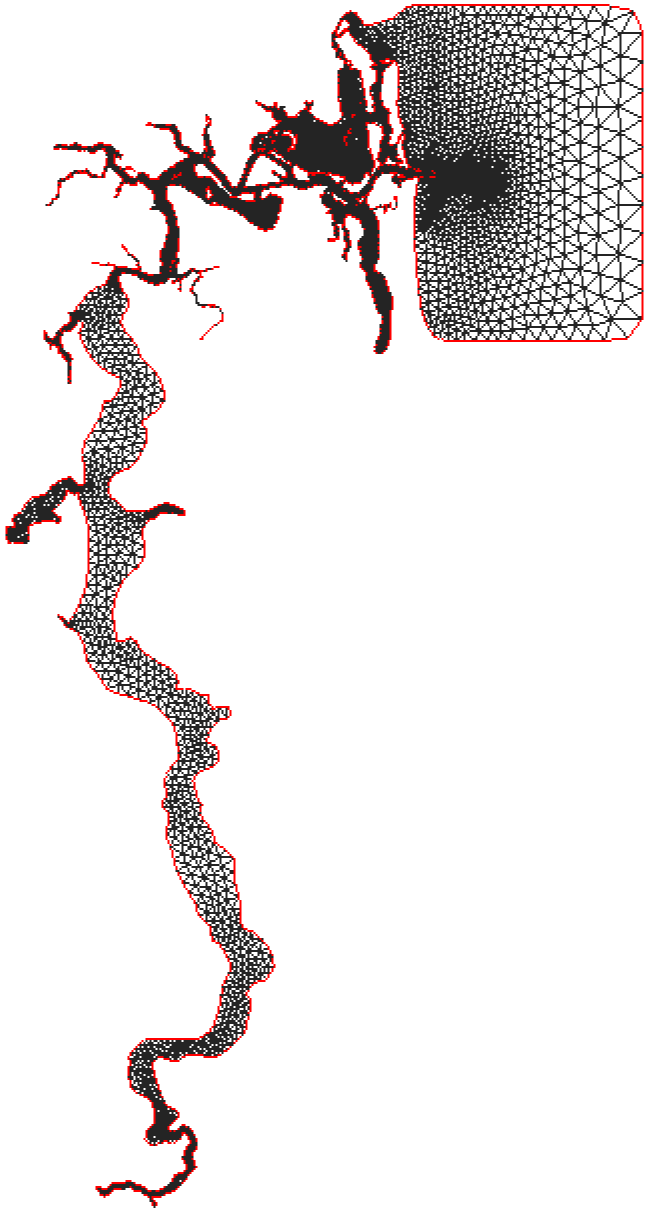

Figure 9. Discretized model domain based on finite elements.

4.0 CALIBRATION AND VALIDATION

4.1 Calibration

Calibration of the Jacksonville Harbor AdH model was accomplished by properly describing the flow parameters, material properties, and boundary and initial conditions to obtain an agreeable match between the observed and computed water levels and velocities. Through a successful calibration, it is ensured that the model would reasonably reproduce the observed data collected during the field measurement program. The calibration consisted of an iterative trial and error approach that minimized the differences between measured data and computed results by changing the calibration parameters. During calibration, the roughness values were changed in the model in order for the simulated outputs to agree with the observed amplitude for water level variation and to agree with the observed velocities. The Manning roughness coefficient can have effects on the amplitude damping and phase delay for the propagation of the tidal signal. To improve the accuracy of the model, Manning roughness coefficient was varied in the model domain.

Initially, the model was calibrated to obtain a reasonably close agreement between simulated and observed tidal fluctuations. Once a reasonable calibration of the tidal fluctuations is achieved, the simulated tidal currents are compared with the measured data. Water level data measured from four locations (selected based on the availability of measured data) were used to compare with the simulated results by AdH. The calibration period extended from June 16, 2009 at 3:00 pm to June 19, 2009 at 3:00 pm. The calibration locations for the water levels and current are shown in Figures 10 and 11, respectively.

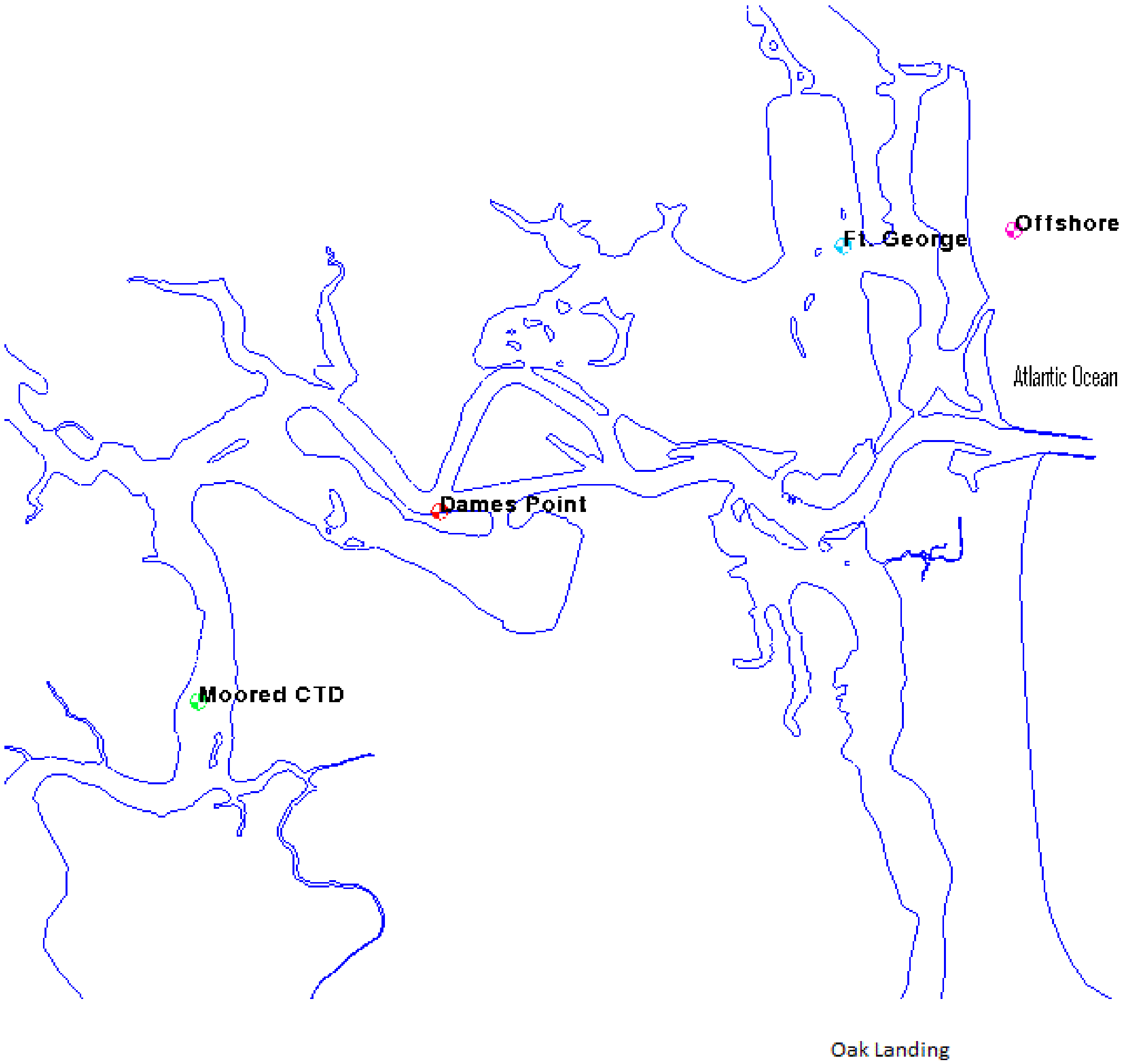

Figure 10. Location for measuring water levels.

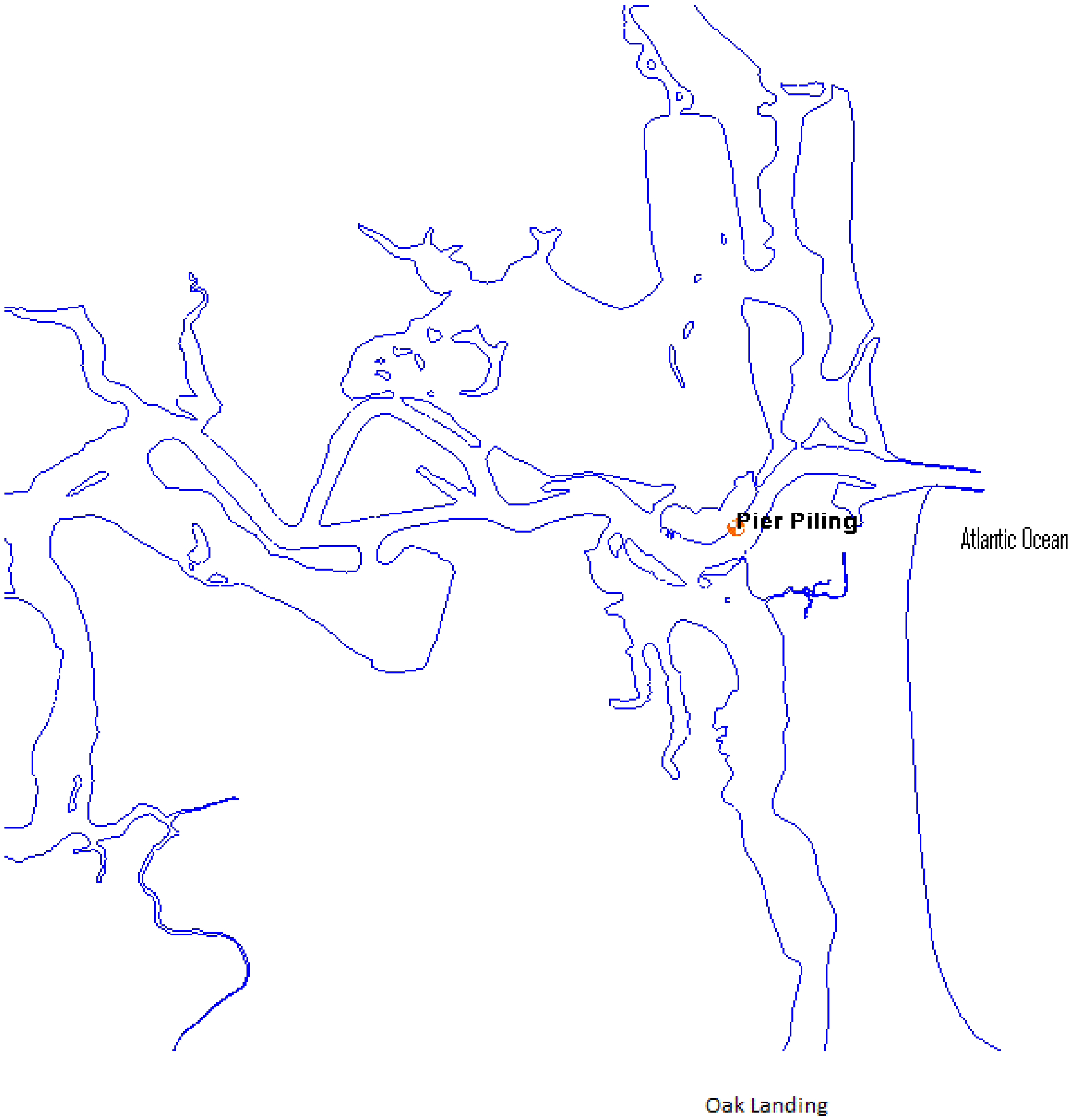

Figure 11. Location for measuring current.

Figures 12 through 15 show the comparisons of the modeled and measured water levels at four locations. Reasonable agreements are shown between the measured data and predicted results. In general, the measurements are reproduced by the model for most periods of the simulations. The agreement is best in the offshore location as shown in Figure 15. The observed and model predicted tidal currents at Pier Piling are shown in Figure 16. The currents show variations caused by the tides. Model predicted currents at Pier Piling location compare well with the observations. The currents at the flood (at 48.58 hours) and ebb (at 54.67 hours) tide conditions were investigated. The spatially varying currents at flood and ebb tide conditions are depicted in Figures 17 and 18, respectively.

The calibration statistics are given in Table 1. As shown in the table, the mean errors are not significant. The mean absolute errors and root mean square errors indicate deviations higher than the mean errors. These values are not significant compared to the overall tidal fluctuations at the locations. It is observed graphically that small deviations in the phase of the tides can cause large deviations between the observed and the simulated water levels. In addition, the statistical comparisons are performed using the interpolated values of the model results. This is done because of the differences in the measurement times and the model output times. The interpolated values can introduce some discrepancies compared to the observed data. Consequently, both graphical and statistical comparisons were made for achieving the calibration of the model. The correlation coefficients are high for the locations where tidal elevations are compared. This indicates a strong association between the observed and the simulated values of the tidal elevations. At Pier Piling, the currents are compared. The statistical comparisons for the currents are not as good as the comparisons shown for the tidal elevations. The measured current data might have the effects of many factors (wakes caused by the nearby vessels and/or the local phenomena such as a vortex in a three-dimensional space) that cannot be represented using a vertically homogeneous model.

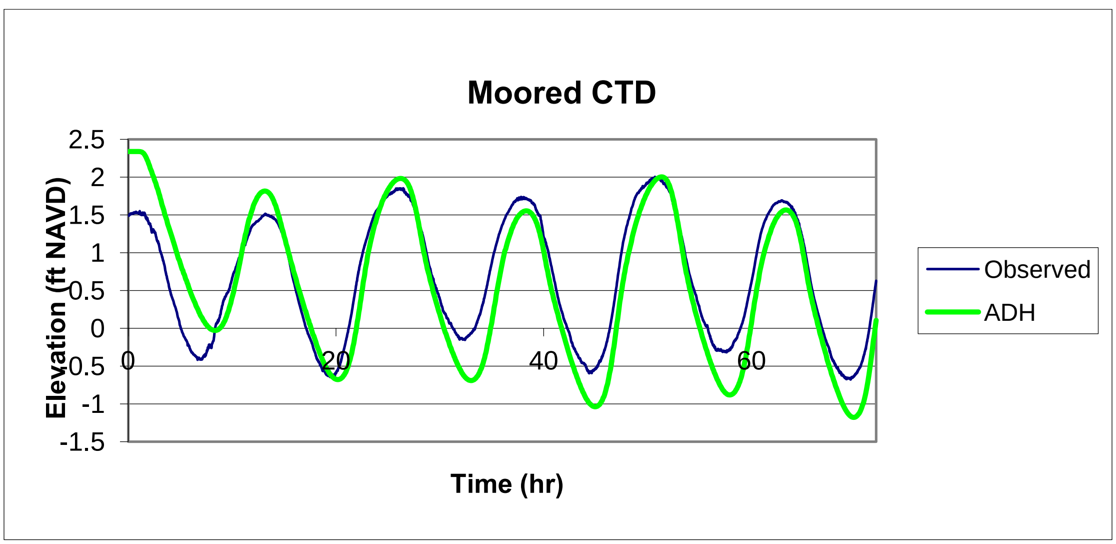

Figure 12. Observed and simulated water levels at Moored CTD from June 16, 2009 at 3:00 pm to June 19, 2009 at 3:00 pm.

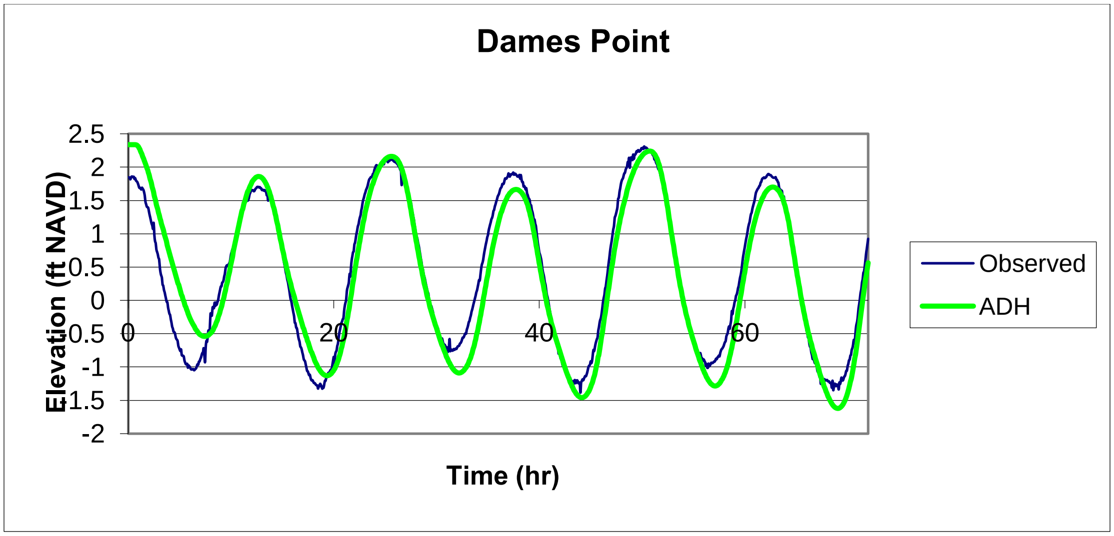

Figure 13. Observed and simulated water levels at Dames Point from June 16, 2009 at 3:00 pm to June 19, 2009 at 3:00 pm.

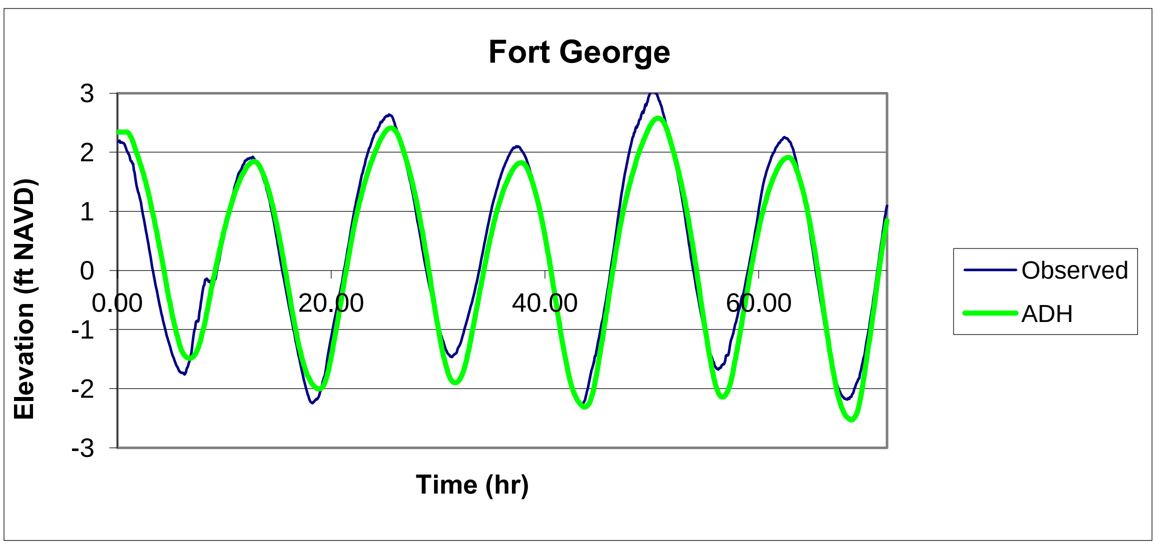

Figure 14. Observed and simulated water levels at Ft. George from June 16, 2009 at 3:00 pm to June 19, 2009 at 3:00 pm.

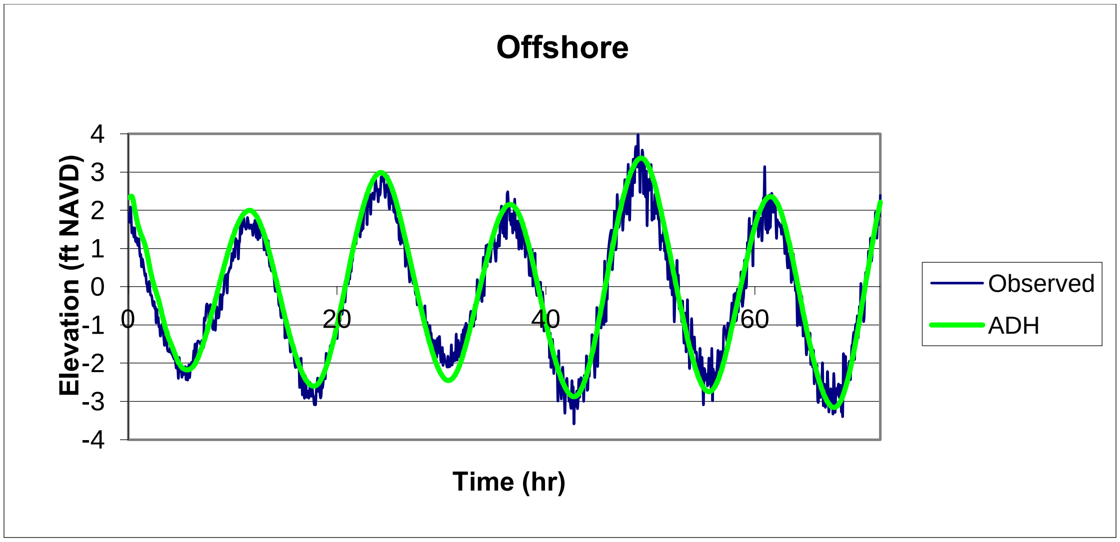

Figure 15. Observed and simulated water levels at Offshore from June 16, 2009 at 3:00 pm to June 19, 2009 at 3:00 pm.

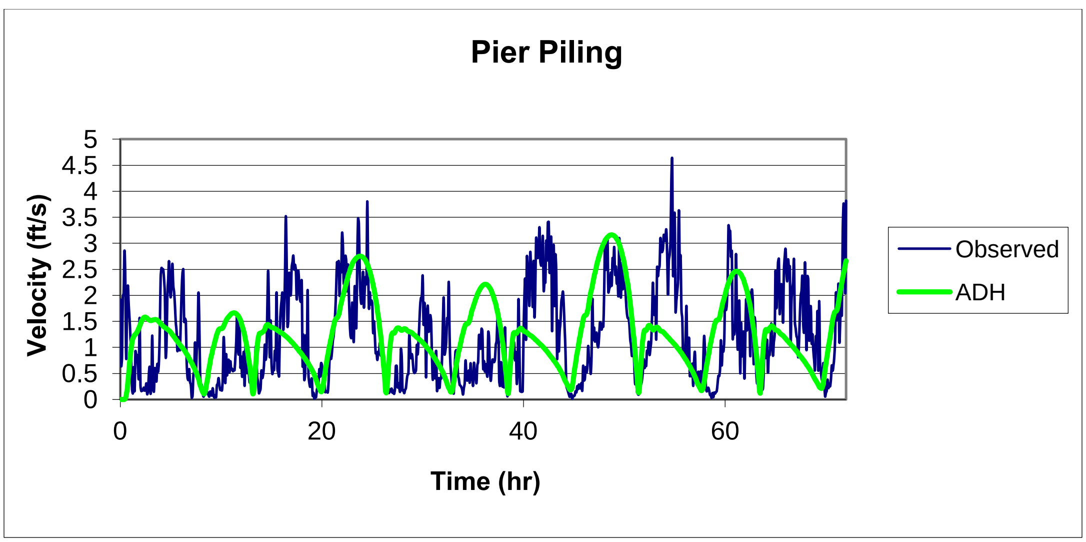

Figure 16. Observed and simulated current speeds at Pier Piling from June 16, 2009 at 3:00 pm to June 19, 2009 at 3:00 pm.

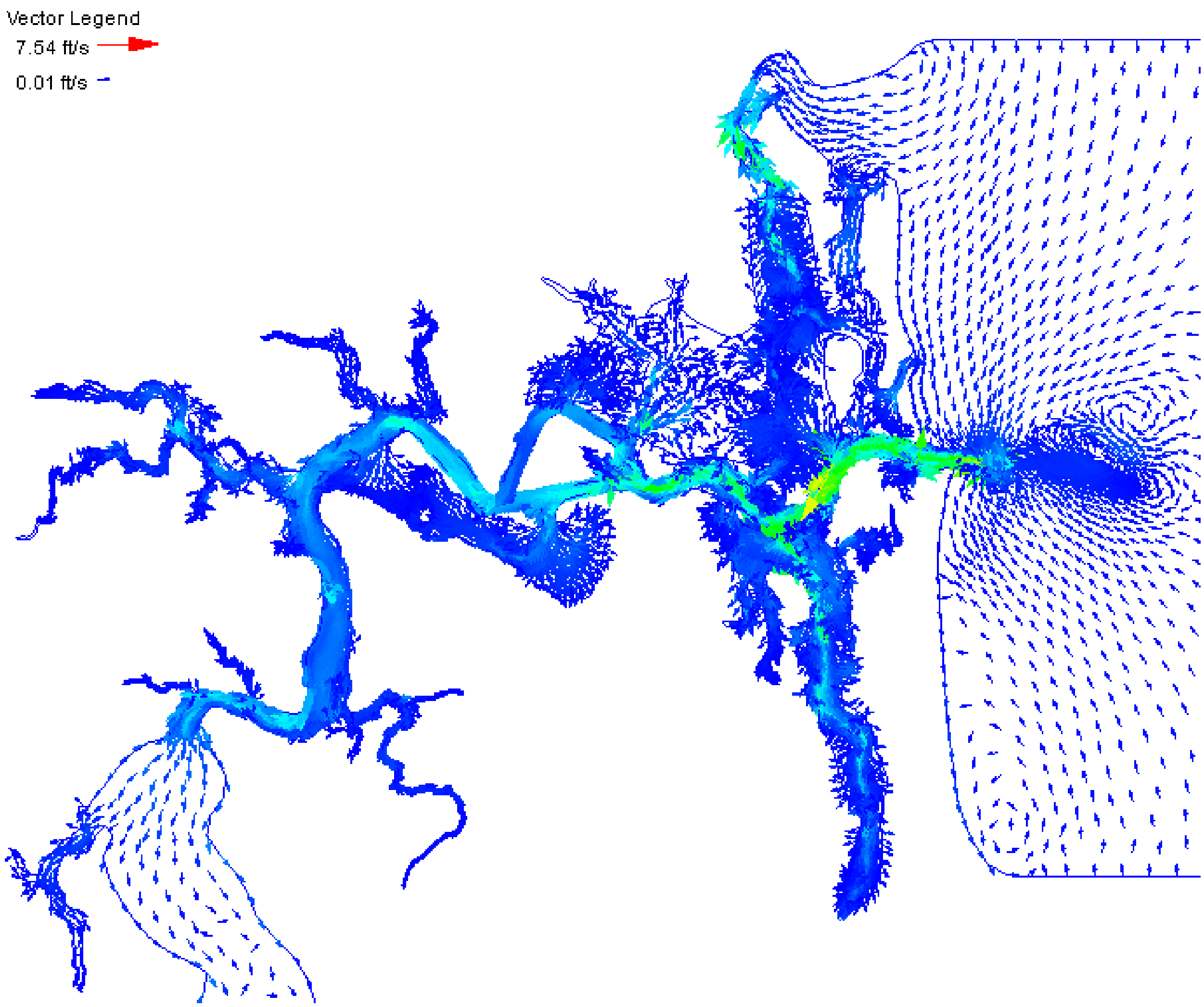

Figure 17. Currents at the flood tide (at 48.58 hours).

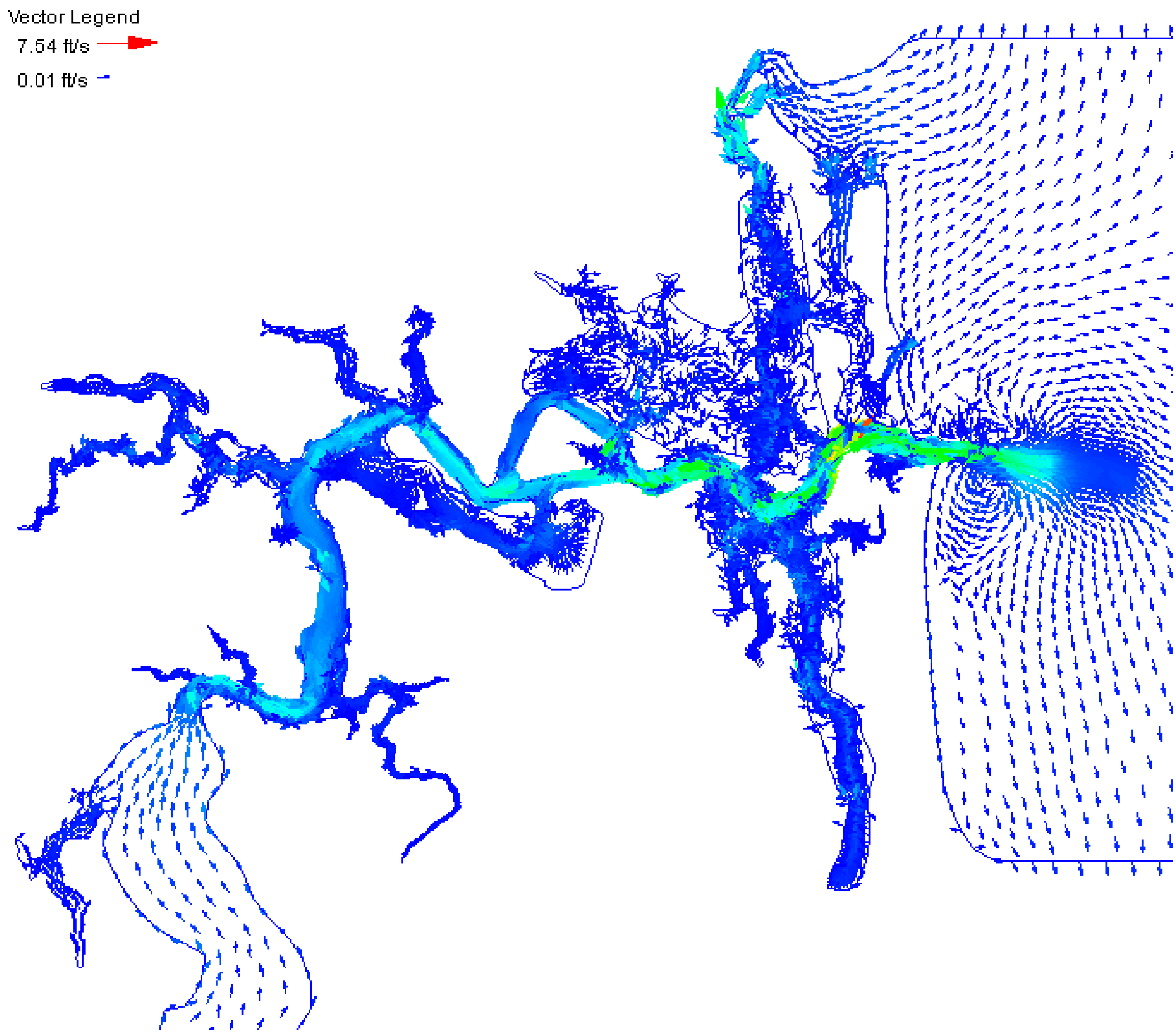

Figure 18. Currents at the ebb tide (at 54.67 hours).

Table 1. Calibration statistics.

Location	Mean Error	Mean Absolute Error	Root Mean Square Error	Correlation Coefficient
Dames Point Bridge[1]	-0.07	0.27	0.35	0.96
Moored CTD[1]	-0.13	0.35	0.42	0.92
Fort George[1]	-0.09	0.29	0.36	0.97
Offshore[1]	0.13	0.34	0.42	0.98
Pier Piling[2]	0.07	0.78	0.95	0.34

1. Tidal elevations (ft NAVD88)
2. Current (ft/s)

4.2 Validation

After calibration, the model was validated by simulating the hydrodynamic conditions for a different time period. This helped verify the accuracy of calibration and validate the model for predictive simulations. The period of simulation for validation is from June 26, 2009 at 12:00 am to June 29, 2009 at 12:00 am. The values of all the input parameters remained the same as for the calibrated model. The boundary conditions were changed to represent the tidal fluctuations for the validation period.

The AdH simulated results were compared with the measured data for the validation period. Figures 19 through 22 shows the comparisons of water levels at the locations where calibration was performed (Figures 10 and 11). The observed data agree closely with the simulated results. The time-varying currents are compared at Pier Piling location for the validation period as shown in Figure 23. The observed speeds have been reproduced reasonably well by the model. It was necessary to perform the validation run and compare simulated results with the observed data for gaining more confidence in the model application.

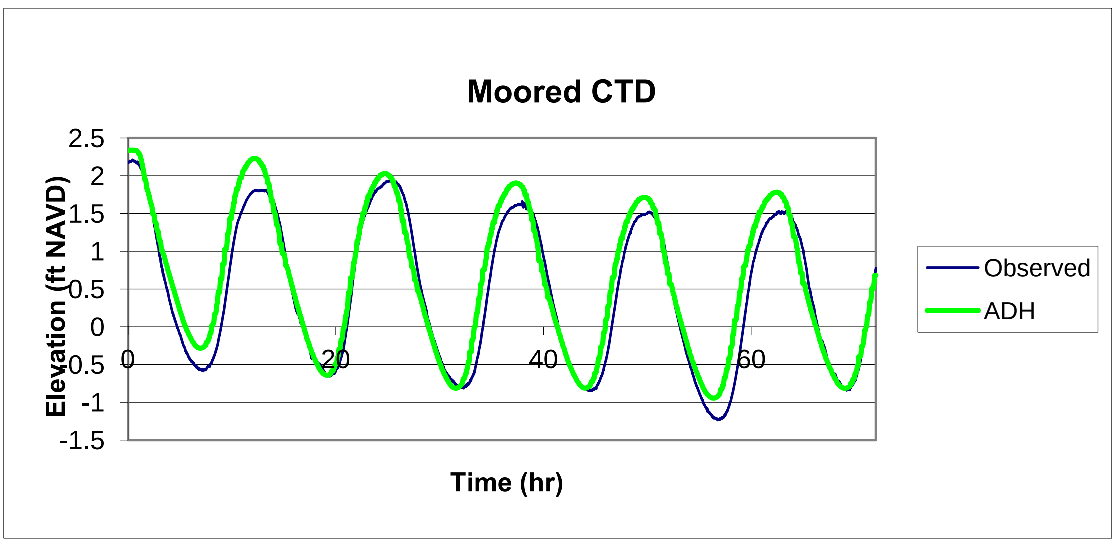

Figure 19. Observed and simulated water levels at Moored CTD from June 26, 2009 at 12:00 am to June 29, 2009 at 12:00 am.

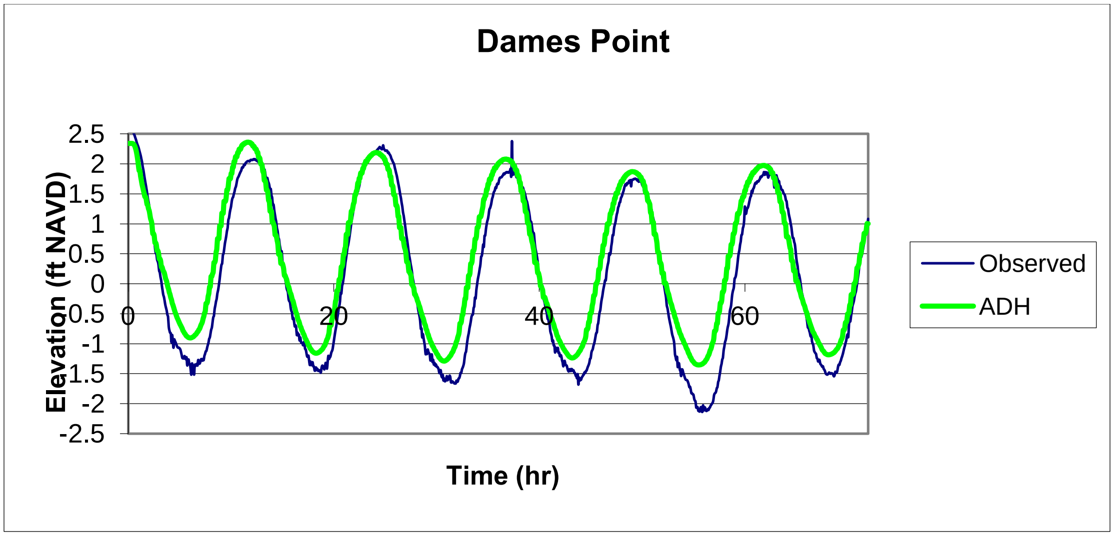

Figure 20. Observed and simulated water levels at Dames Point from June 26, 2009 at 12:00 am to June 29, 2009 at 12:00 am.

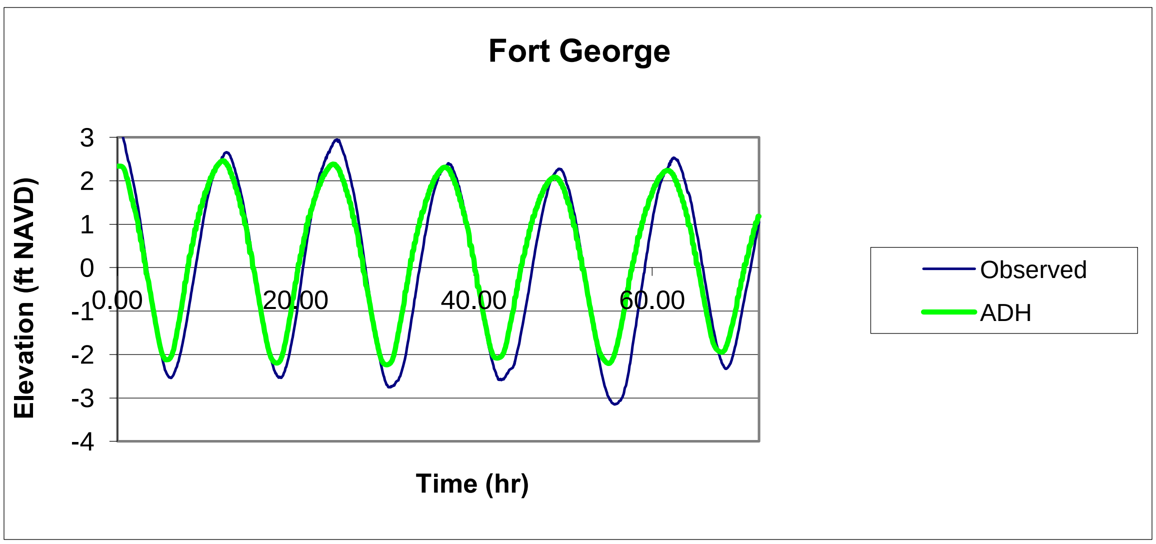

Figure 21. Observed and simulated water levels at Fort George from June 26, 2009 at 12:00 am to June 29, 2009 at 12:00 am.

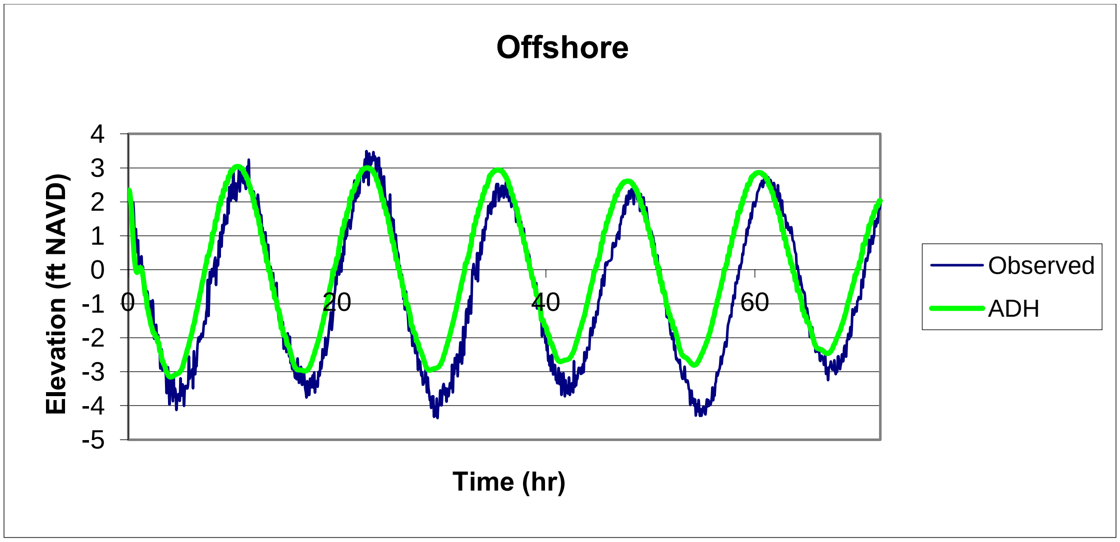

Figure 22. Observed and simulated water levels at Offshore from June 26, 2009 at 12:00 am to June 29, 2009 at 12:00 am.

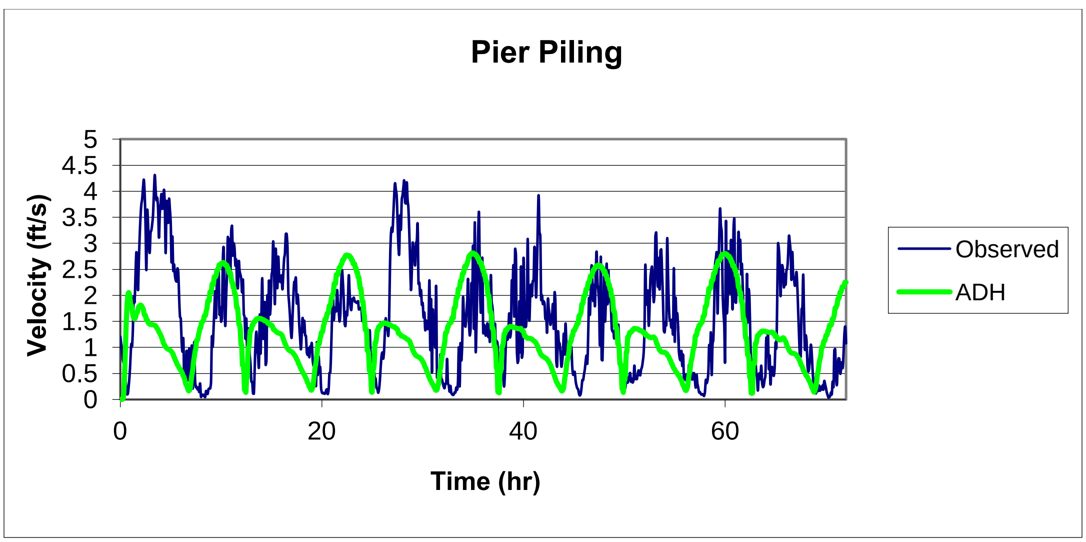

Figure 23. Observed and simulated current speeds at Pier Piling from June 26, 2009 at 12:00 am to June 29, 2009 at 12:00 am.

4.3 Sensitivity Analysis

A priori analysis of the sensitivity of the input parameters was done before and during calibration. The values of the coefficients describing the eddy viscosity and the wetting-drying limit were changed to see their effects on the stability and efficiency of the model. It was found that the stability and efficiency of the model was affected by the change in the values of the wetting-drying limit. The runtime of the model is decreased by increasing the wetting-drying limit. The wetting-drying limit describes a water depth below which the solution stability parameters are applied within AdH. Increasing the wetting-drying limit promotes model stability. Using a trial-and-error approach, this value was established. With higher values of the wetting-drying limit, the model is allowed to proceed and converge in the wetland areas.

A number of trial runs were performed. Once the model was stable, the effects of the Manning's roughness coefficient were analyzed. It was observed that the amplitudes of the tides increase due to the decrease of the values of the roughness coefficients. Conversely, the amplitudes decreased with the increase of the roughness coefficient. This occurs due to the increased dissipation of the energy due to the higher values of the coefficient of roughness. All these analysis based on the changes in the values of the parameters were helpful in adjusting the model in reproducing the field conditions during calibration.

5.0 SIMULATION OF ALTERNATIVES FOR SHIP SIMULATIONS

Following the calibration and validation of the existing condition model, the model mesh was then modified to represent the physical geometry/bathymetry of the different deepening and widening alternatives. AdH simulation of these different project alternatives then produced the hydrodynamics that was furnished to ERDC for incorporation into their ship simulation studies that would ultimately evaluate and verify the navigational performance and safety of the different project alternatives. For dredging scenarios, the simulations were performed by changing the channel bathymetry (channel depth, channel width, turn wideners and turning basins). In the present modeling study, seven alternatives (1, 2, 3, 2a, 2b, 4, and 5) were simulated. The footprints for all the alternatives extend from Atlantic Ocean to Talleyrand Terminal.

A description of the alternatives is given in Table 2. In the description of the alternatives, the location of Broward Point and Cut 41 are shown in Figure 3. All other locations mentioned in Table 2 are shown in Figure 3. The alternatives vary with respect to the extent of widening and deepening along the course of the federal channel. The deepening is done by 48 ft toward the west and 50 ft toward the east from Broward Point (Figure 3). Through post-processing the results, the currents for flood tide and ebb tide conditions were extracted and were provided to the ship simulators at ERDC.

Table 2. Description of Ship Simulation alternatives.

Alternative	Description
1	Widening in the Federal channel at the north of the entrance to Mill Cove, Dames Point Bulk Terminal, and Interim Cruise Ship Terminal, and Talleyrand Terminal.
2	Widening in the Federal channel at Mile Point, Cut 41, the north and south of the entrance to Mill Cove, Dames Point Bulk Terminal, Interim Cruise Ship Terminal, Broward Point, Navy Fuel Depot, ST (Oil) Services, and Talleyrand Terminal.
3	Widening in the Federal channel at the west of Mile Point, Cut 41, north of entrance to Mill Cove, Dames Point Bulk Terminal, Interim Cruise Ship Terminal, Broward Point, Navy Fuel Depot, ST (Oil) Services, and Talleyrand Terminal.
2a	Widening in the Federal channel at Mile Point, Cut 41, north and south of the entrance to Mill Cove, Dames Point Bulk Terminal, Interim Cruise Ship Terminal, Broward Point, Navy Fuel Depot, ST (Oil) Services, and Talleyrand Terminal.
2b	Widening in the Federal channel at Mile Point, Cut 41, north and south of the entrance to Mill Cove, Dames Point Bulk Terminal, Interim Cruise Ship Terminal, Broward Point, Navy Fuel Depot, ST (Oil) Services, and Talleyrand Terminal, and.
4	Widening in the Federal Channel at Mile Point, west of Mile Point, Cut 41, north of entrance to Mill Cove, Dames Point Bulk Terminal, Interim Cruise Ship Terminal, Navy Fuel Depot, ST (Oil) Services, and Talleyrand Terminal.
5	Widening in the Federal Channel at Mile Point, west of Mile Point, Cut 41, north and south of entrance to Mill Cove, Dames Point Bulk Terminal, Interim Cruise Ship Terminal, Broward Point, Navy Fuel Depot, ST (Oil) Services, and Talleyrand Terminal.

6.0 NUMERICAL MODEL FOR SEDIMENT TRANSPORT

6.1 AdH Sediment Transport Model for Jacksonville Harbor

Since the hydrodynamic modeling was done using AdH, it was employed to represent the sediment transport processes in Jacksonville Harbor. The model was set up to represent the erosion-deposition processes. To represent the sediment transport processes in Jacksonville Harbor, the types of sediments and their spatial variations along the channel were investigated. These data were analyzed by the USACE-SAJ-Geotechnical Branch and were used for developing the sediment transport model.

Based on the geotechnical analysis, the information of the sediment bed was obtained. The thickness of the sediments at the surface of the channel bed is 0.61 m (2 ft). It is underlain by less erodible rock. The sediments in the AdH are simulated as constituents. Each sediment class is modeled as a constituent. The constituents in the sediment transport model were identified based on the geotechnical investigation and identification of the sediment types in the Jacksonville Harbor.

6.2 **Sediment Classes in Jacksonville harbor**

The sediment types in the Jacksonville Harbor include coarse sand, medium sand, fine sand, silt, and clay. There is not a significant amount of coarse sand available in the sediments. Overall, the coarse sand comprises about six percent of the total sediments. For this study, coarse sand and medium sand were combined into one class of materials. Similarly, silt and clay were grouped as one class. Based on the geotechnical analysis, the classes of sediments were grouped using the overall percentage of their availability as follows:

- Coarse/medium sand (20 percent)
- Fine sand (57 percent)
- Silt/clay (23 percent)

The overall percent distributions of the three classes of sediments are shown above in parentheses. However, the distribution varies along different reaches in the harbor. The spatially varying distributions of the three sediment classes were described in the AdH model.

6.3 Sediment Transport Model Results

The primary objective of the sediment transport modeling analysis was to simulate the effects of the dredging on the displacement of the bed and shoaling caused by the sedimentation processes. The simulations were made for the existing condition and for the with-project condition at a dredging depth of 46 ft. It is relevant to mention that additional AdH modeling will be done for the Locally Preferred Plan, which is the Tentatively Selected Plan, with an inner channel project depth of 47 ft MLLW and a length which extends from Mile 0 to Mile 13.1. This work will be completed prior to and included in the final draft of this GRR.

The bathymetry for the existing condition and the with-project 46-ft depth dredging condition is shown in Figure 24 and 25, respectively. Both the existing and with-project conditions were run for three months starting from May 1, 2009 through July 31, 2009. The tidal elevations were assigned along the north, south, and west boundary of the model domain in the Atlantic Ocean. The tidal elevations were also assigned at the southern boundary for the Intracoastal Waterway near Oak Landing. These data were obtained from the ADCIRC model. At Buffalo Bluff, the time-varying flow rates collected from a USGS gage were assigned.

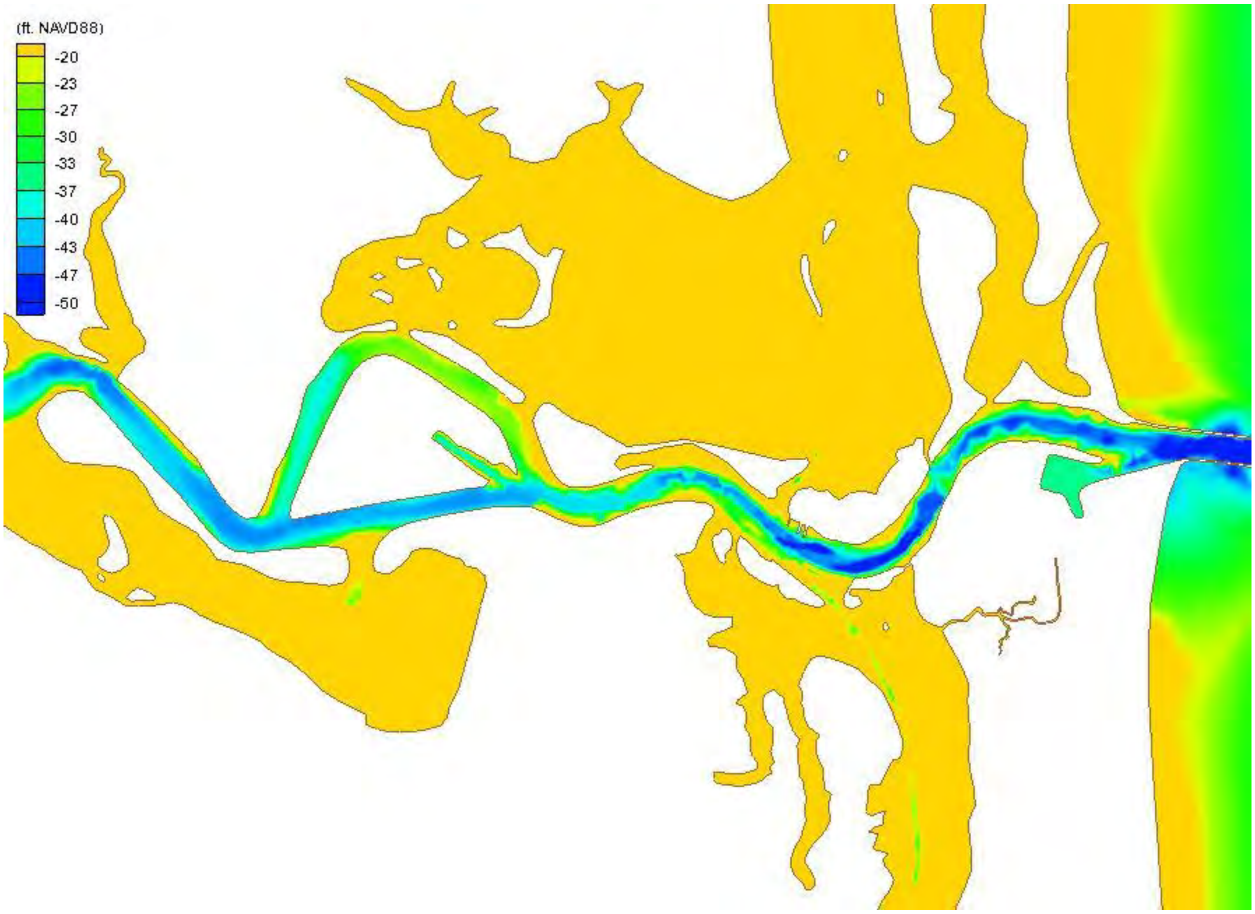

Figure 24. Bathymetry for existing condition.

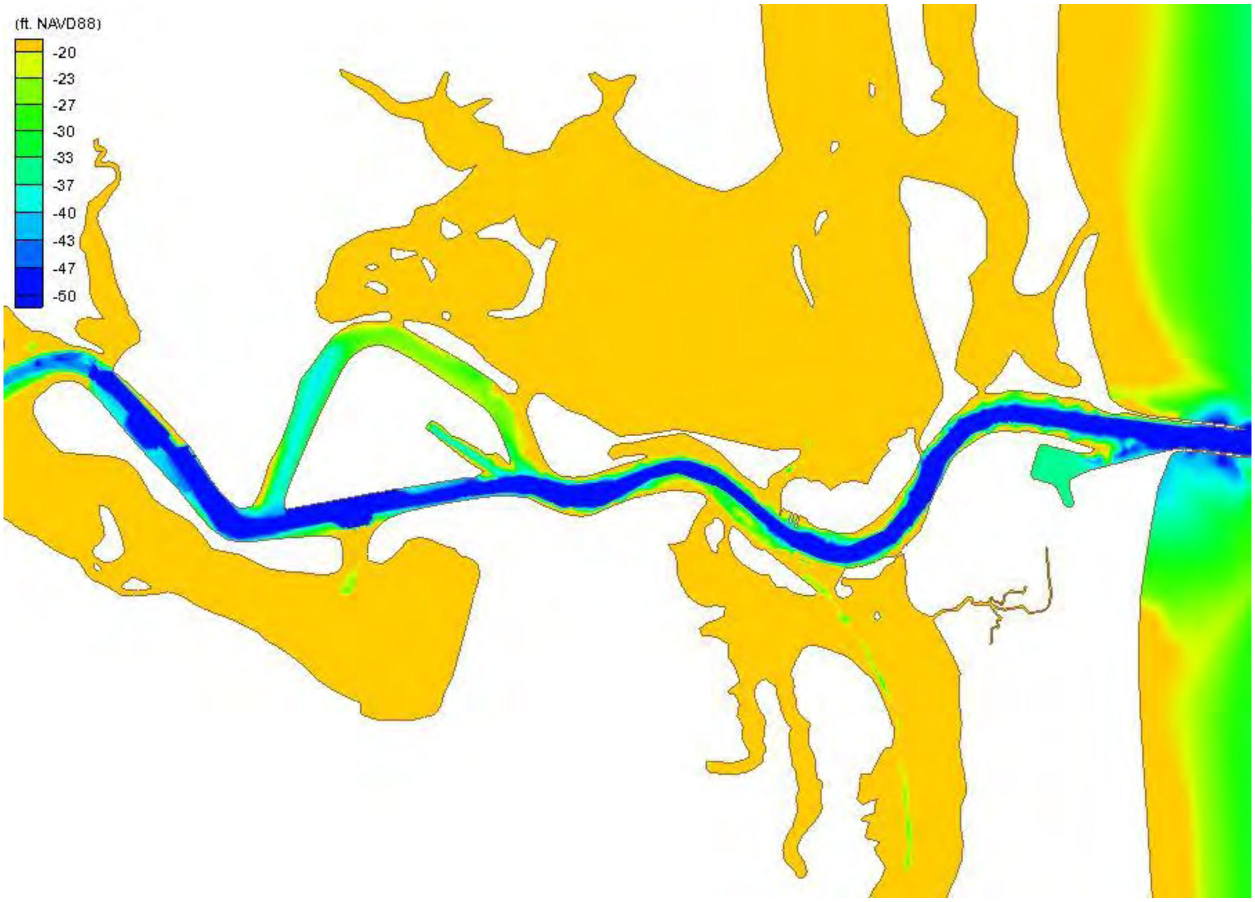

Figure 25. Bathymetry for with-project (46-ft depth) condition.

To reduce uncertainty in the modeling, the simulated bed elevations were compared with the observed variations at eight locations as shown in Figure 26. The observed and simulated bed levels at these locations are shown in Figure 27. The observed data were collected during March through May in 2009. At the end of three-month simulation (July 31, 2009), the bed levels are compared with the observed data. The comparisons are made to see whether the simulated bed levels are within a reasonable limit.

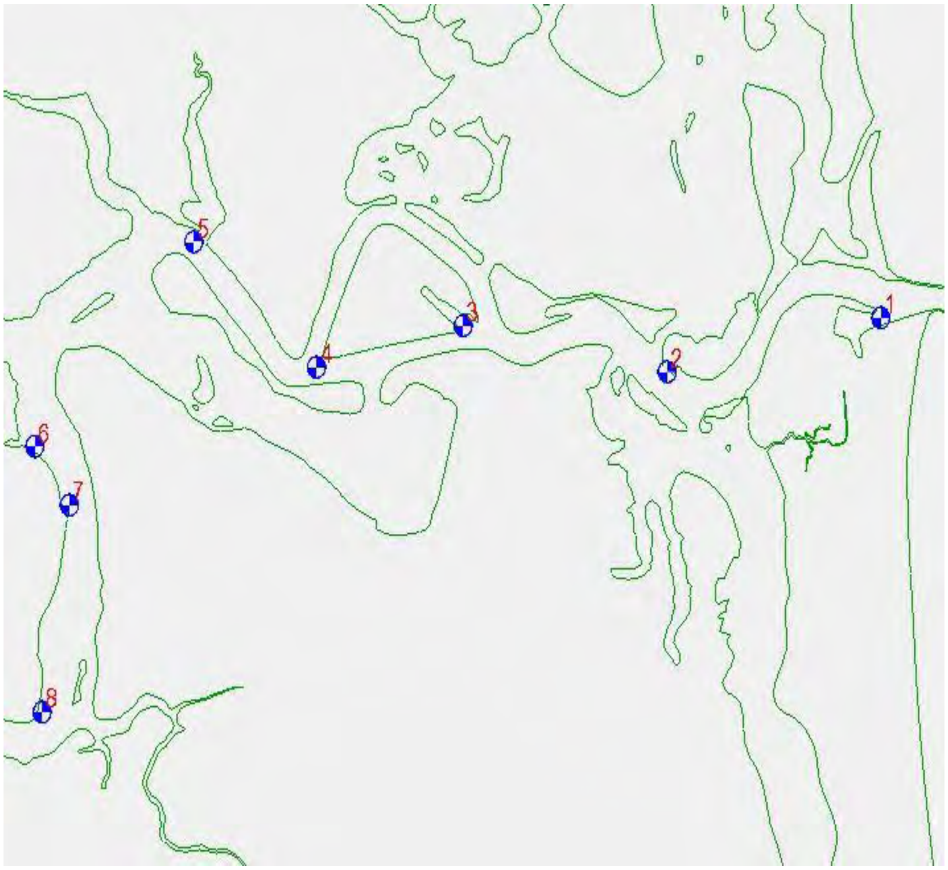

Figure 26. Locations for comparisons of bed levels.

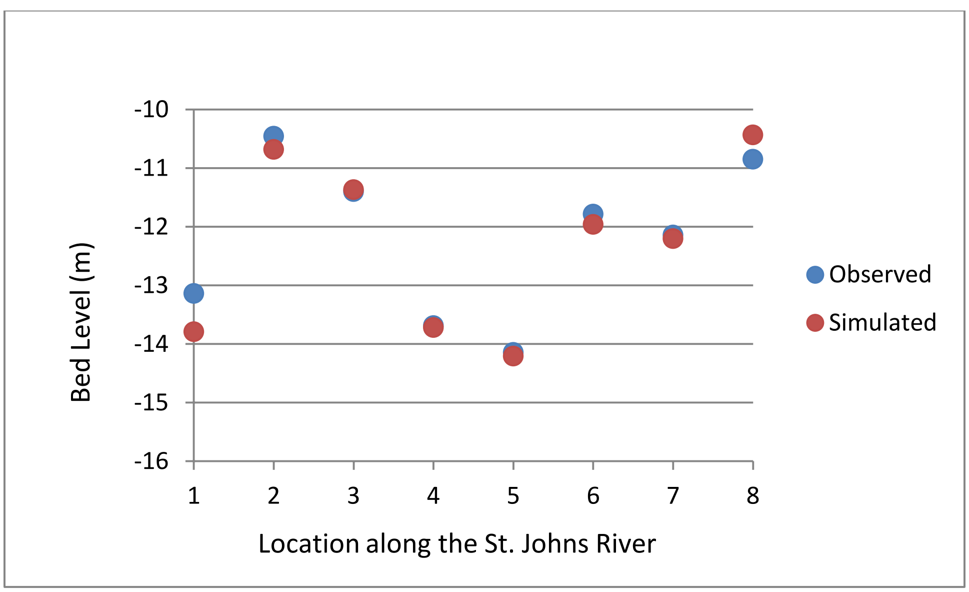

Figure 27. Comparisons of observed and simulated bed level.

In the Federal Channel, the currents for the existing condition and with-project condition can also be compared to gain some insight on potential areas for erosion and accretion due to the deepening and widening project. The differences in the magnitudes of the currents are shown in Figures 28 (July 28, 2009) and 29 (July 31, 2009) at two different simulation times. The color fill contours indicate that there are both increase and decrease in currents at different times at the same location along the channel. So, the net effects on the currents due to dredging will not be significant. The currents at ten different locations along the channel are investigated. The locations are shown in Figure 30. The values of currents at these locations for the existing and with-project (46-ft) depth are shown in Table 3.

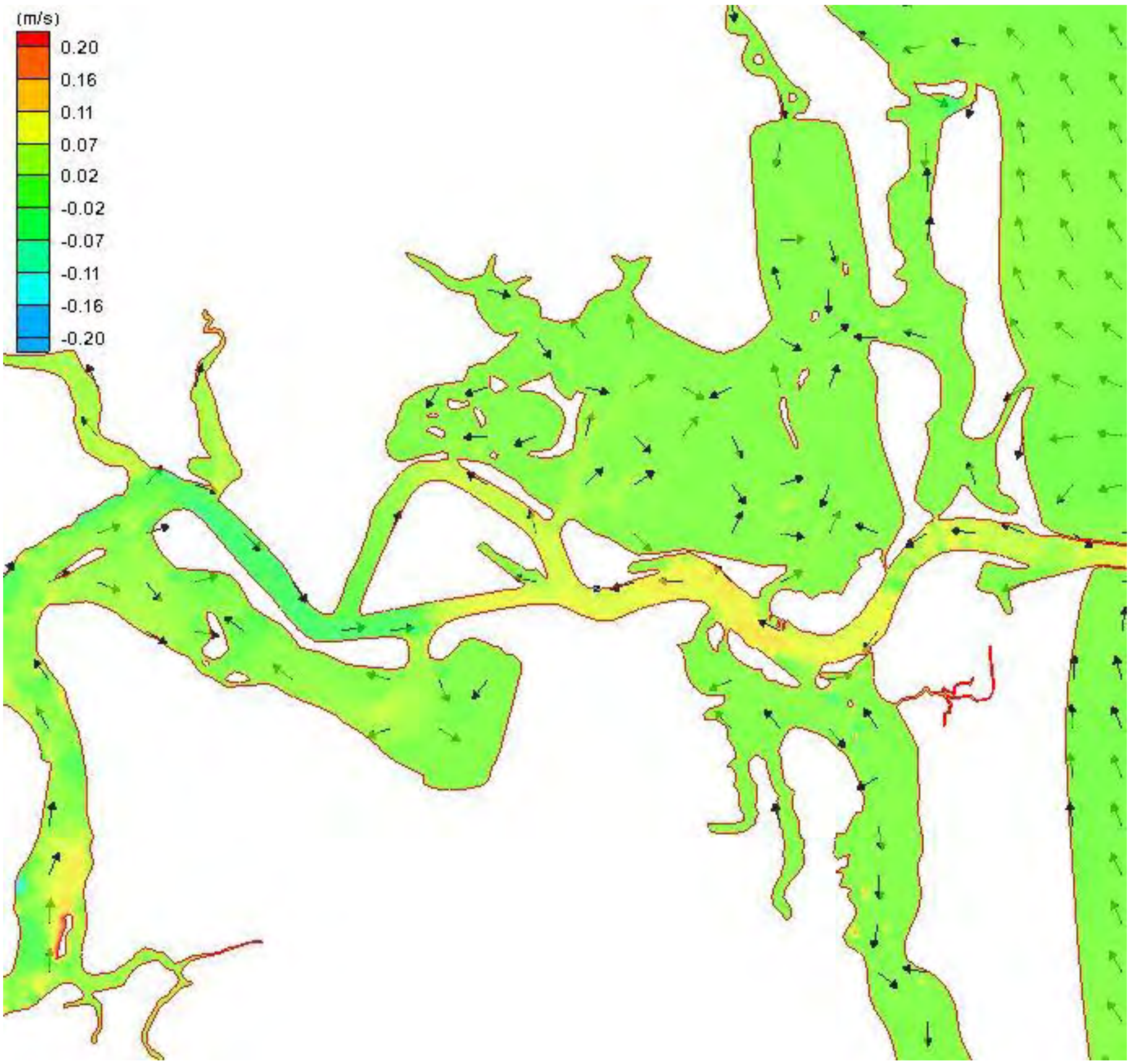

Figure 28. Difference in currents between with-project (46-ft depth) and existing condition on July 28, 2009 (Flood Tide).

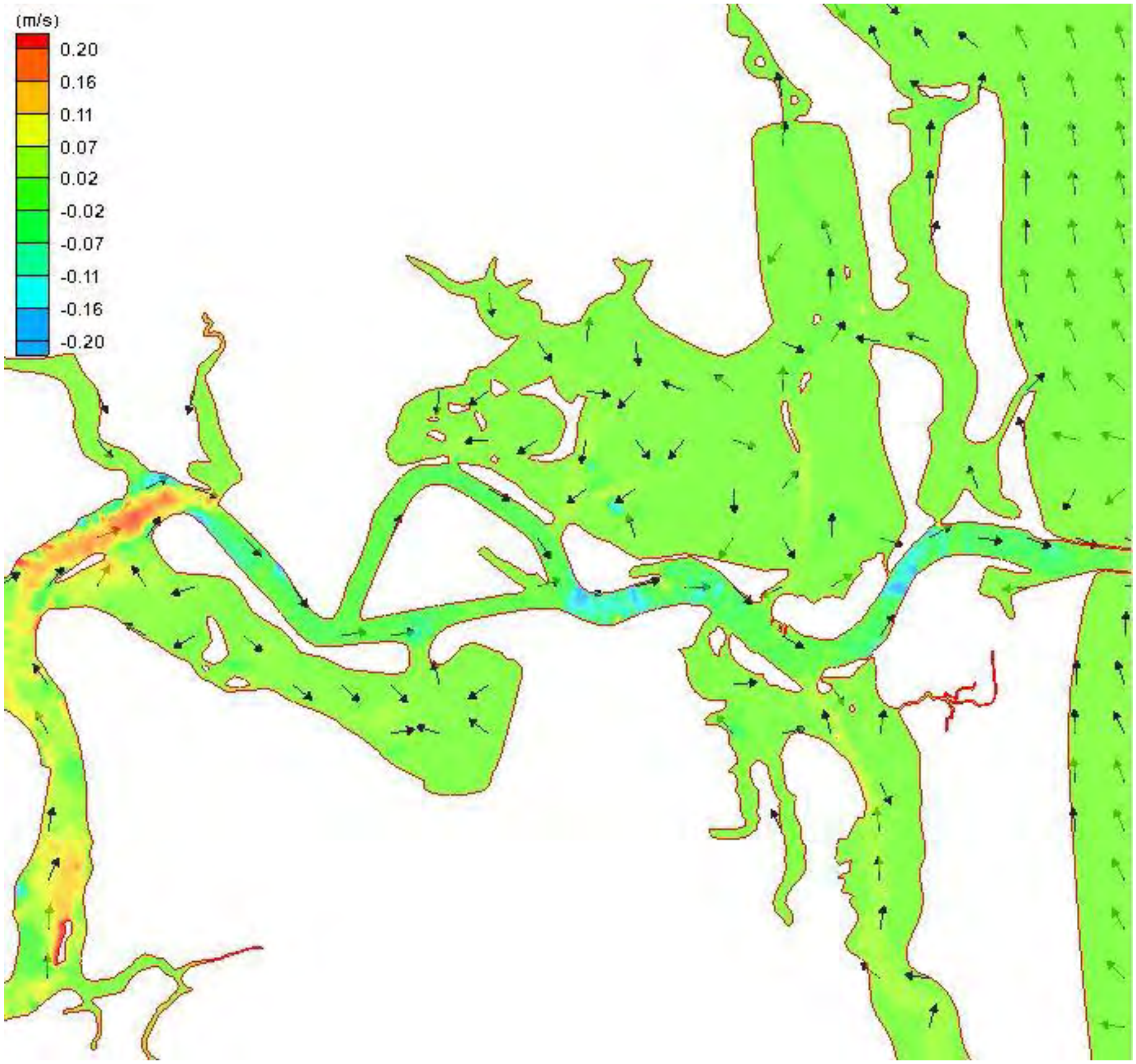

Figure 29. Difference in currents between with-project (46-ft depth) and existing condition on July 31, 2009 (Ebb Tide).

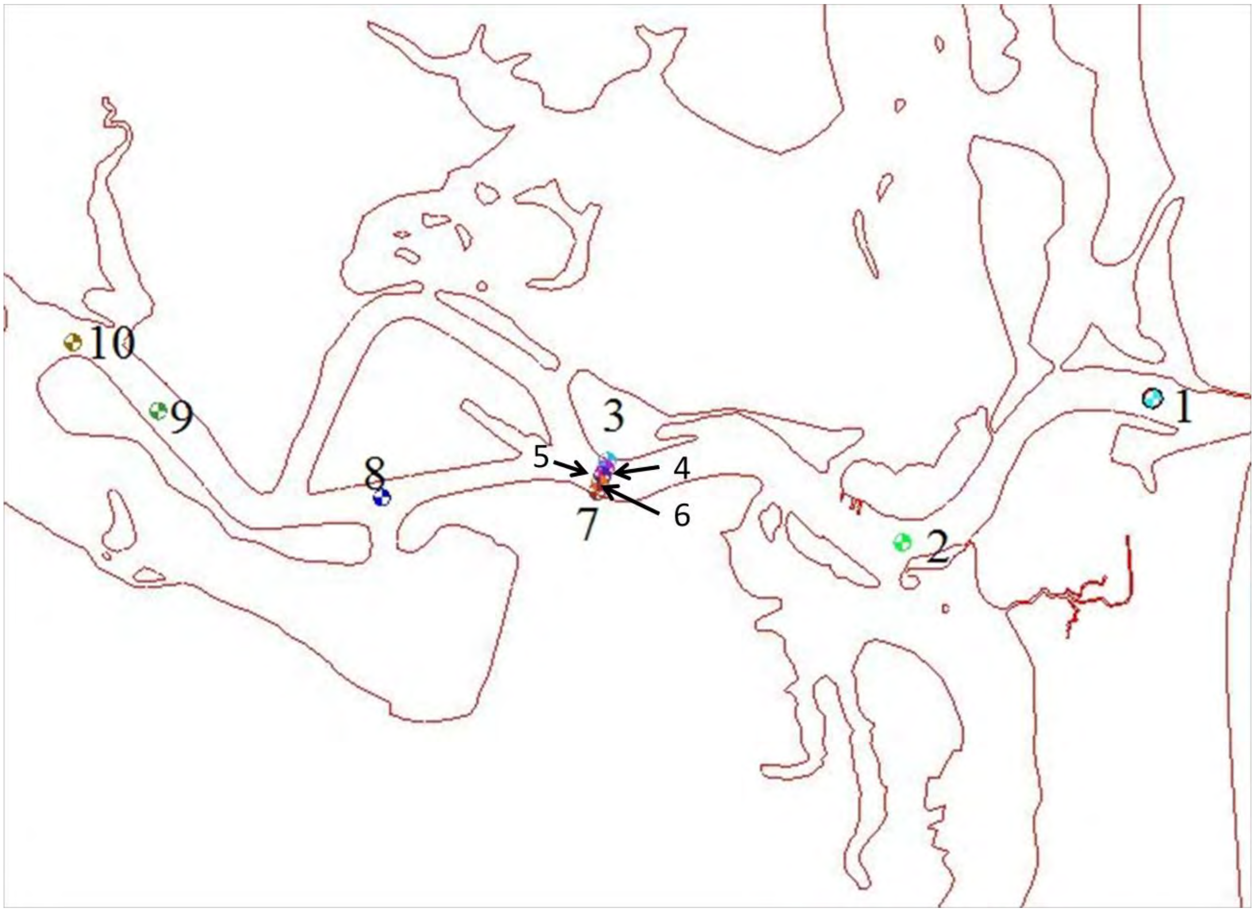

Figure 30. Locations for comparing currents.

Table 3. Comparison of currents (ft/s) in the channel.

Location	Existing condition			With-project (46-ft depth) condition		
	Minimum	Maximum	Average	Minimum	Maximum	Average
1	0.001	4.63	1.61	0.004	4.51	1.59
2	0.06	3.84	1.47	0.06	3.99	1.50
3	0.01	3.01	1.24	0.004	2.70	1.06
4	0.02	3.64	1.44	0.02	3.04	1.18
5	0.02	3.89	1.55	0.005	3.22	1.24
6	0.01	3.28	1.42	0.004	2.97	1.19
7	0.01	2.49	1.29	0.004	2.36	1.03
8	0.06	1.94	0.83	0.04	1.74	0.69
9	0.001	2.13	0.92	0.008	1.83	0.77
10	0.01	2.27	0.97	0.01	2.95	1.15

At the end of 3-month AdH sediment transport simulation (May through July, 2009), the shoaling depths are investigated. The shoaling depths for the existing and project conditions (46-

ft depth) are shown in Figures 31 and 32, respectively. Along the Federal Channel, the shoaling volumes from May through July have been computed for the existing and project conditions. The shoaling volumes are shown in Table 4. Of the estimated total 3-month shoaling volume of 16,707 yd^3 for Section 2, the turning basin at Mill Cove for with-project condition contributes 16,067 yd^3. A total of 96 percent of the shoaling occurs at the turning basin in Section 2. Of the estimated total 3-month shoaling volume of 5,769 yd^3 for Section 3A, the Mill Cover turning basin for with-project condition contributes 4,672 yd^3. A total of 81 percent of the shoaling occurs within the turning basin area. Overall, the results estimate that the dredging causes an increase in shoaling volume by fifteen percent when considering the three dredging sections defined in Table 4. The widening of the channel at the entrance to the Mill Cove contributes to the shoaling as shown in Figure 32.

Figure 31. Shoaling for existing condition (May through July, 2009).

Figure 32. Shoaling for project (46 ft depth) condition (May through July).

Table 4. 3-Month AdH Model Predicted Shoaling Volume (May through July, 2009)

Scenario	Mayport to Mile Point (Section 1, Cut 3 to Cut 13)	Mile Point to Mill Cove (Section 2, Cut 14/15 to Cut 42)	Turning Basin near Bartram Island (Section 3A, Cut-43 to Cut-45)	Total
Existing condition (yd^3)	54,051	2,728	0	56,780
With-Project (46-ftdepth condition) (yd^3)	42,666	16,707: M.C. TB 16,707: TOTAL	4,672: B.I. TB 5,769: TOTAL	65,142

The average shoaling rates (based on the rates of bed displacement) are computed at the turning basin in the Mill Cove and Bartram Island area. Based on the average modeled shoaling rate of 0.0034 ft/day, an annual increase of 1.25 ft is predicted for the turning basin at the Mill Cove area. Similarly, based on an average modeled shoaling rate of 0.0044 ft/day, an annual increase of 1.6 ft in the bed is predicted for the turning basin near Bartram Island.

7.0 BANK EFFECTS

As noted in Table 3, current velocities (both average and maximum) within the main channel are predicted to decrease from the existing condition to the with-project condition for Locations 1 and 3 - 9. This can be explained by the increased cross-sectional flow area in the larger project channel (typically deeper and wider) resulting in slightly diminished flow velocities (V=Q/A) since the magnitude of the combined freshwater flows and tidal prism flows will remain mostly unchanged in the downstream reaches of the river. Only Location 2 shows a slight predicted increase in current velocities for the with-project condition. Since the northern river bank near Location 2 and the North Bank of Cut 41 have previously experienced bank erosion and slope failures, it was prudent to more closely examine the model predicted current velocities along the banks in these areas under the existing and with-project conditions.

7.1 Cut-41 North Bank

The variations of water levels and currents at the north bank in the Cut-41 area were examined during the 3-month AdH simulation for May through July 2009. The time-varying model results are extracted at a point at the north bank as shown in Figure 33. The variations of tidal elevations for the existing and with-project (46-ft depth) conditions are shown in Figure 34. As shown in the figure, the water levels do not show any significant difference between the existing and with-project conditions.

The currents at the north bank in the Cut-41 area for the existing and with-project conditions are compared as shown in Figure 35. The currents show an overall decrease for with-project condition compared to the existing condition. There are slight increases at a few times during the simulation period. The average and maximum velocities for the existing conditions are 1.3 ft/sec and 3.1 ft/sec. Maximum flood and maximum ebb velocities for the existing condition are 1.83 ft/sec (at 480 hours) and 1.62 feet/sec (at 237 hours). The average and maximum velocities for the with-project conditions are 1.04 ft/ sec and 2.62 ft/sec. Maximum flood and maximum ebb velocities for the with-project condition are 1.36 ft/sec (at 480 hours) and 0.33 feet/sec (at 237 hours). For closer review, the currents for June 20, 2009 (1200 hrs) to June 28, 2009 (1400 hours) are plotted as shown in Figure 36.

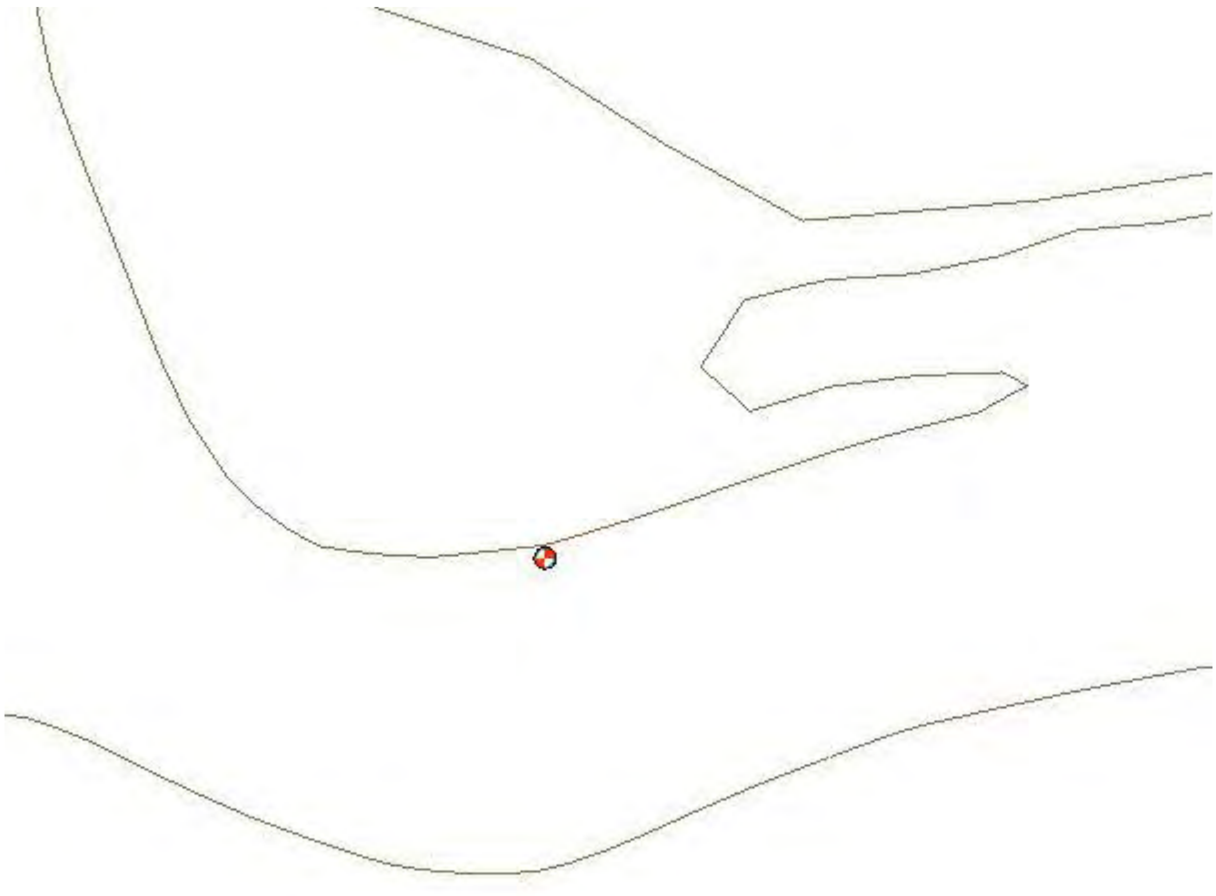

Figure 33. Location at the north bank in the Cut-41 area for comparing water levels and currents.

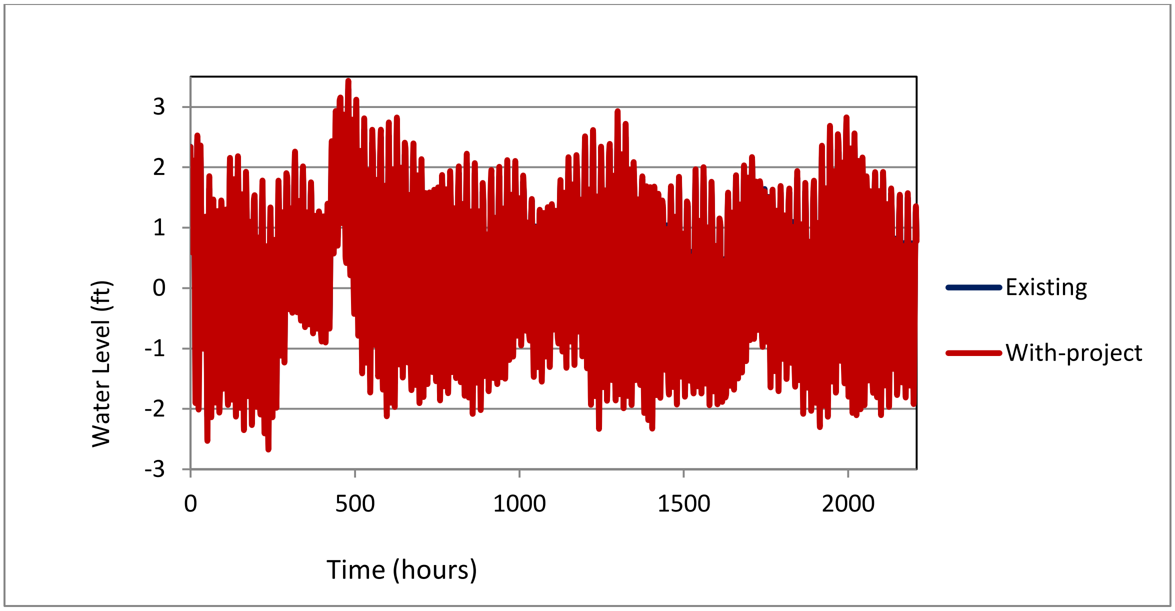

Figure 34. Variations of tidal elevations at the north bank in Cut-41 area (May 1, 2009 to July 31, 2009).

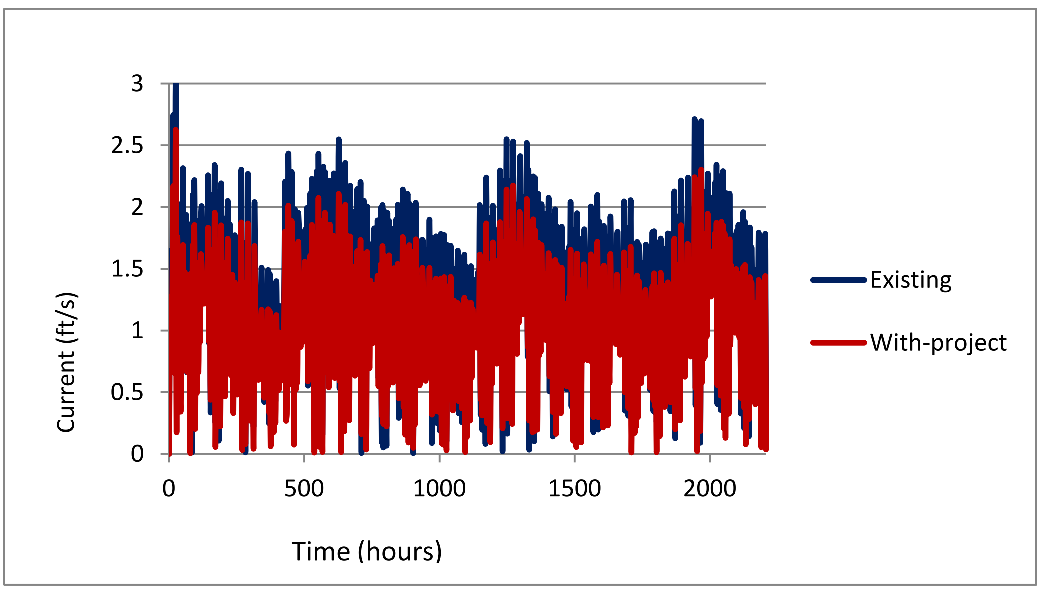

Figure 35. Variations of currents at the north bank in Cut-41 area (May 1, 2009 to July 31, 2009).

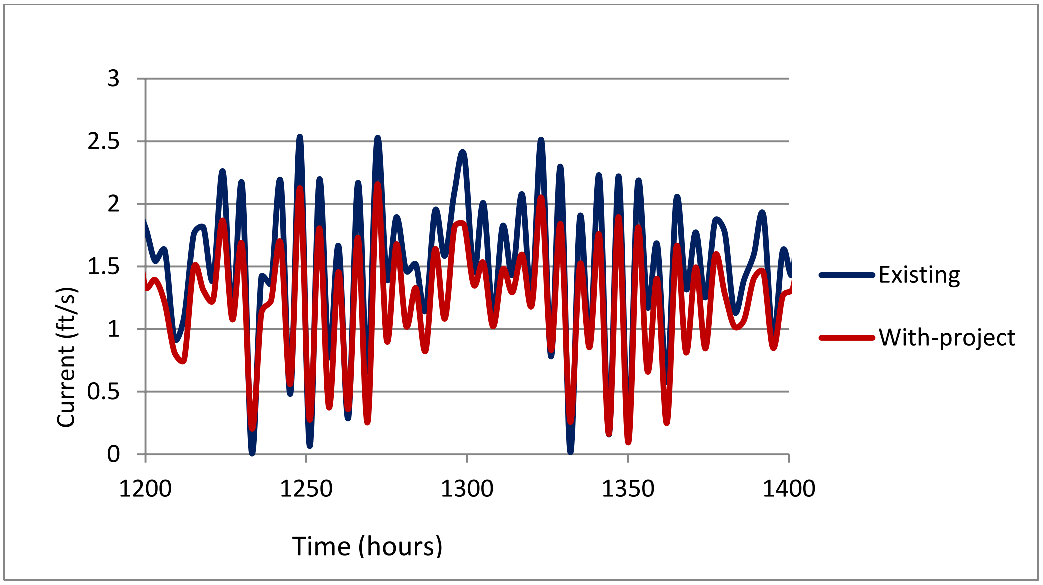

Figure 36. Variations of currents at the north bank in Cut-41 area (June 20, 2009 to June 28, 2009).

7.2 Mile Point North Bank

The variations of water levels and currents at the north bank in the Mile Point area were examined during the 3-month AdH simulation for May through July 2009. The time-varying model results are obtained at a point near the north bank as shown in Figure 37. The comparisons of tidal elevations for the existing and with-project conditions at the point near the bank are shown in Figure 38. As shown, the water level comparisons do not show any significant difference between the existing and with-project conditions.

The currents for the existing and with-project conditions at the north bank in the Mile Point area are compared as shown in Figure 39. The currents do not show any significant difference between the existing and with-project conditions. The average and maximum velocities for the existing conditions are 1.12 ft/sec and 3.05 ft/sec. Maximum flood and maximum ebb velocities for the existing condition are 1.58 ft/sec (at 453 hours) and 3.05 feet/sec (at 24 hours). The average and maximum velocities for the with-project condition are 1.13 ft/ sec and 3.13 ft/sec. Maximum flood and maximum ebb velocities for the with-project condition are 1.57 ft/sec (at 453 hours) and 3.13 feet/sec (at 24 hours). For closer review, the currents for June 20, 2009 (1200 hrs) to June 28, 2009 (1400 hours) are plotted as shown in Figure 40.

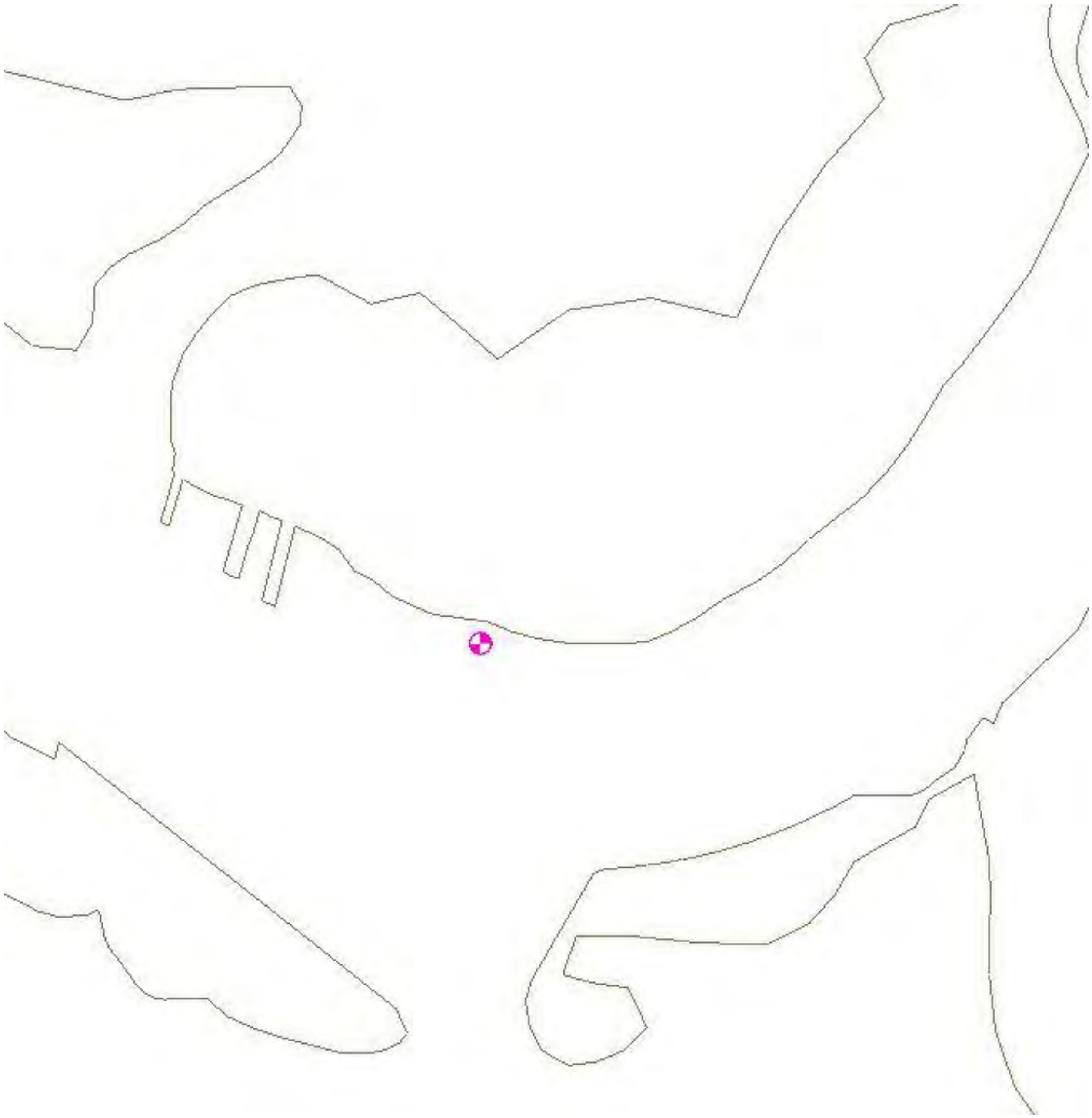

Figure 37. Location at the north bank in the Mile Point area for comparing water levels and currents.

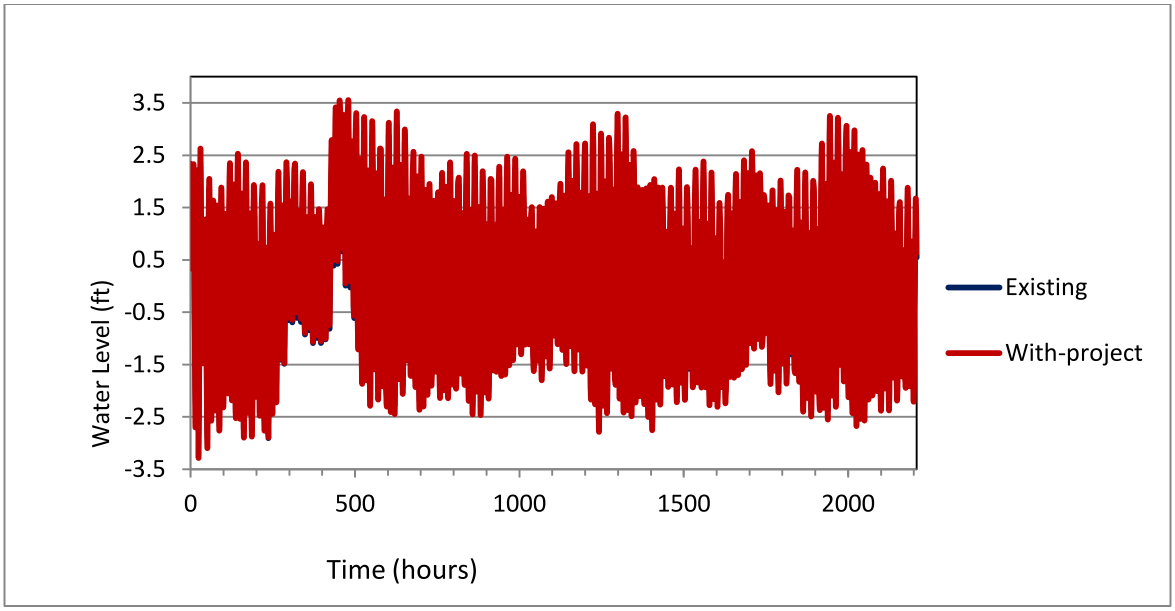

Figure 38. Variations of tidal elevations at the north bank in the Mile Point area (May 1, 2009 to July 31, 2009).

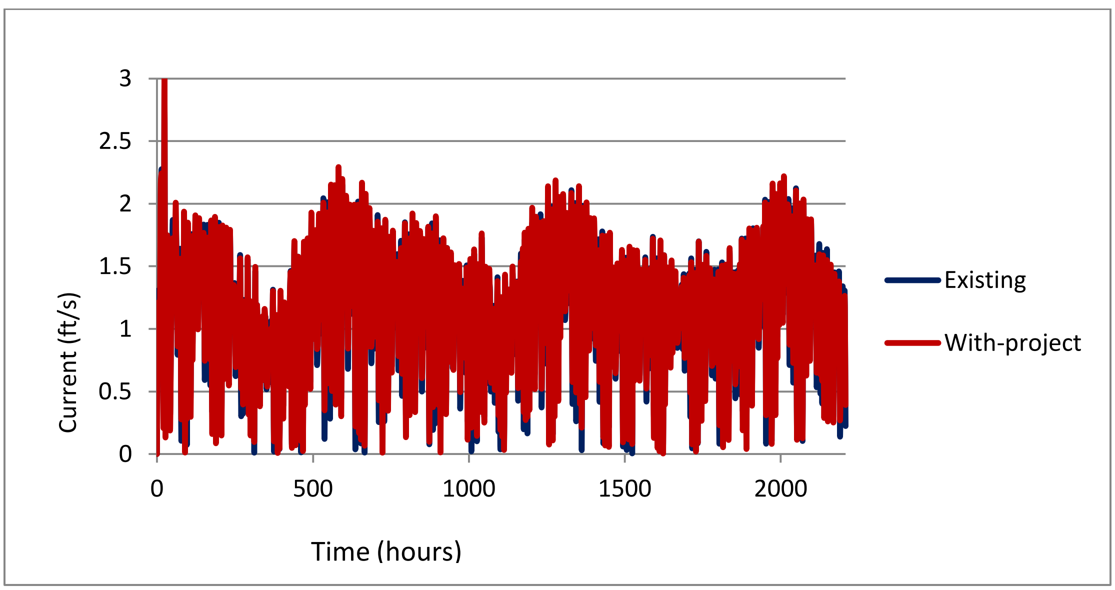

Figure 39. Variations of currents at the north bank in the Mile Point area (May 1, 2009 to July 31, 2009.

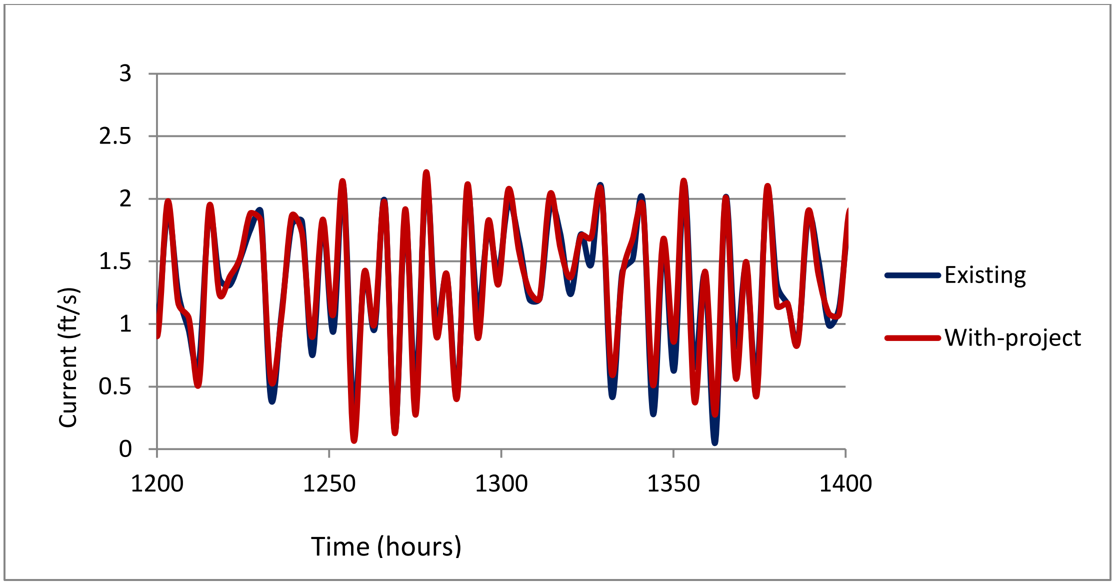

Figure 40. Variations of currents at the north bank in the Mile Point area (June 20, 2009 to June 28, 2009).

8.0 NUMERICAL MODEL FOR MILL COVE BENEFICIAL USE OF DREDGE MATERIALS

At the request of the Jacksonville Harbor GRR2 Project Delivery Team, a hydrodynamic modeling study has been performed to investigate the effects of creating islands as a beneficial use of dredged material in Mill Cove, located on the St Johns River in Jacksonville, Florida. The proposed project location is shown in Figure 41. Four island configurations (Scenarios 1-4) have been proposed as shown in Figures 42 through 45. This modeling analysis utilized the existing AdH hydrodynamic model developed and calibrated for the Jacksonville Harbor GRR2 project. The purpose of this analysis was to simulate the effects of the proposed islands on tidal water levels, water velocities, and flow exchange into and out of Mill Cove. It should be noted that this modeling effort does not account for the effects of wind.

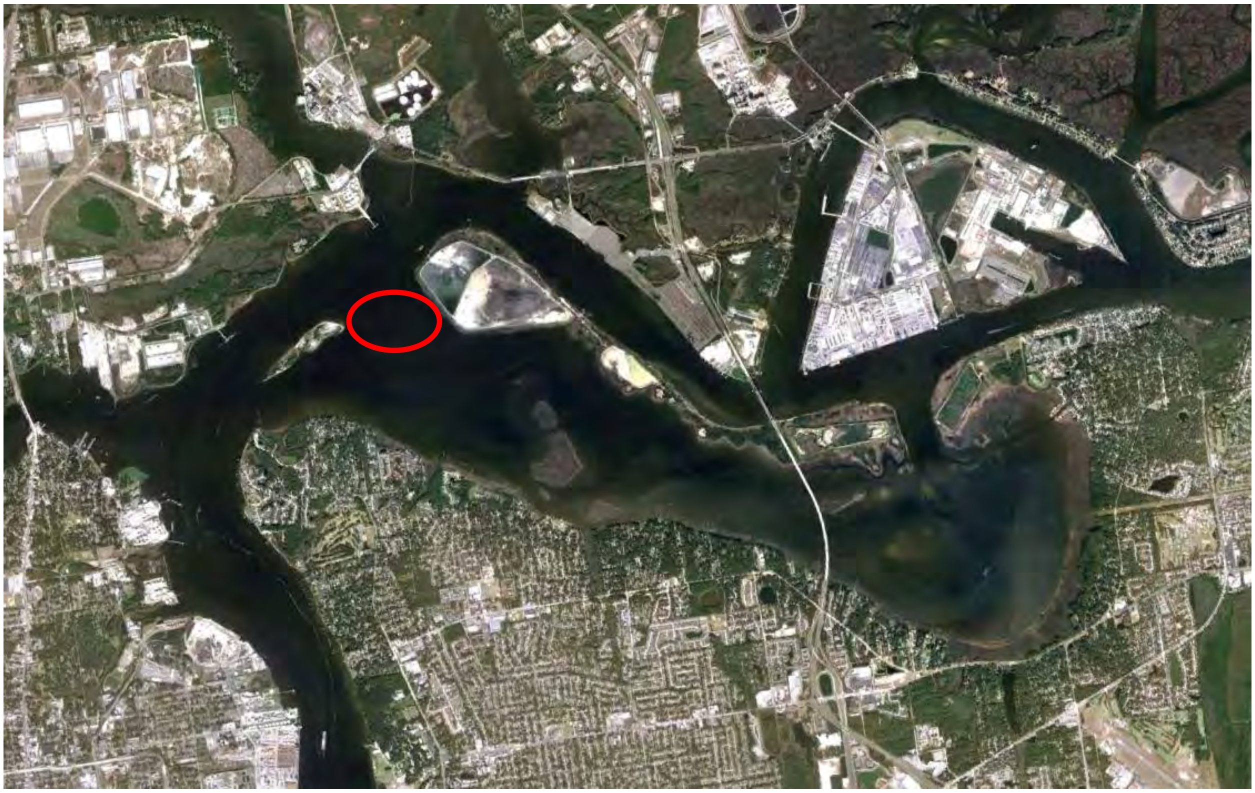

Figure 41. Proposed project location (shown in red).

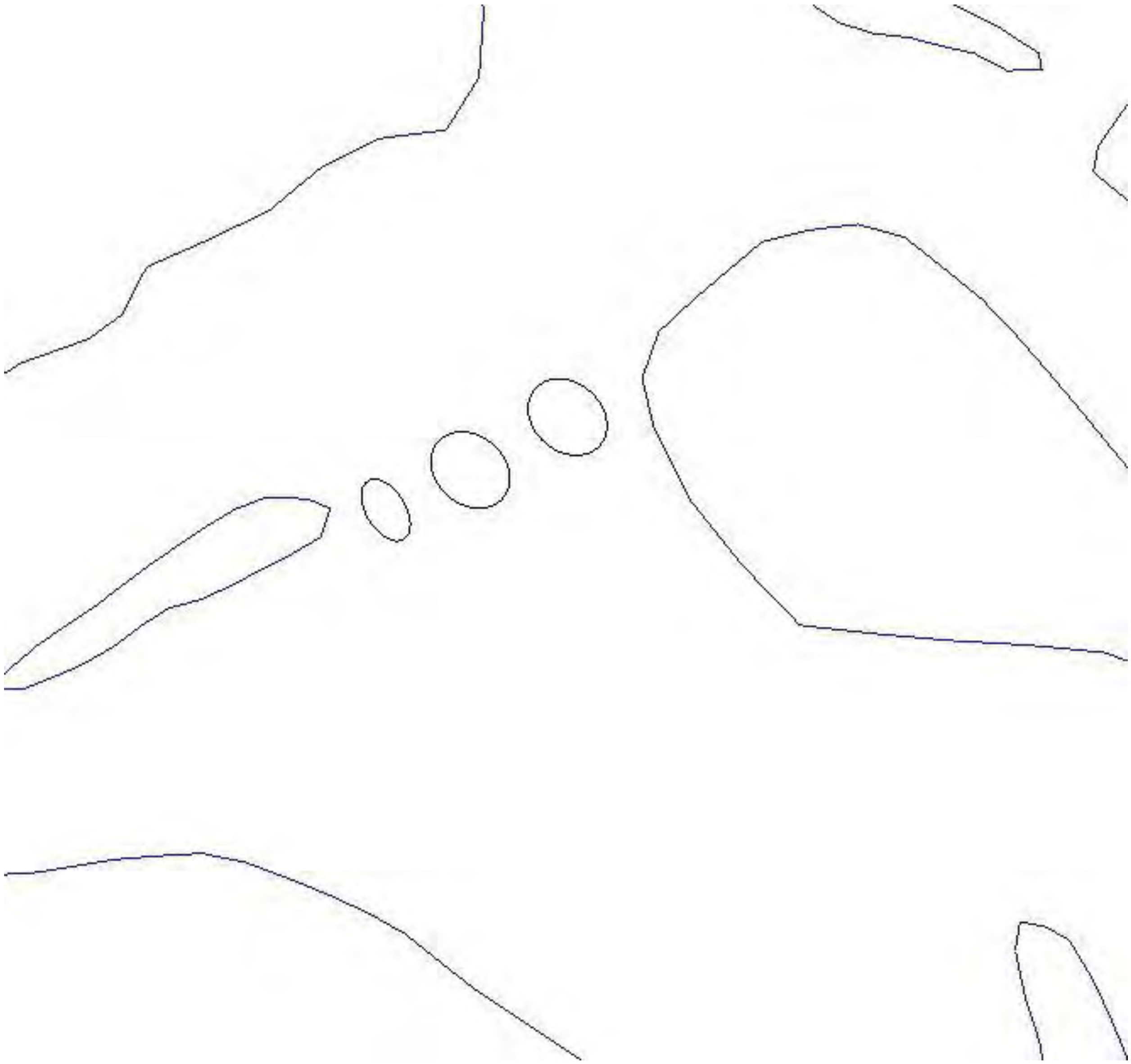

Figure 42. Proposed Mill Cove island alignment for Scenario 1.

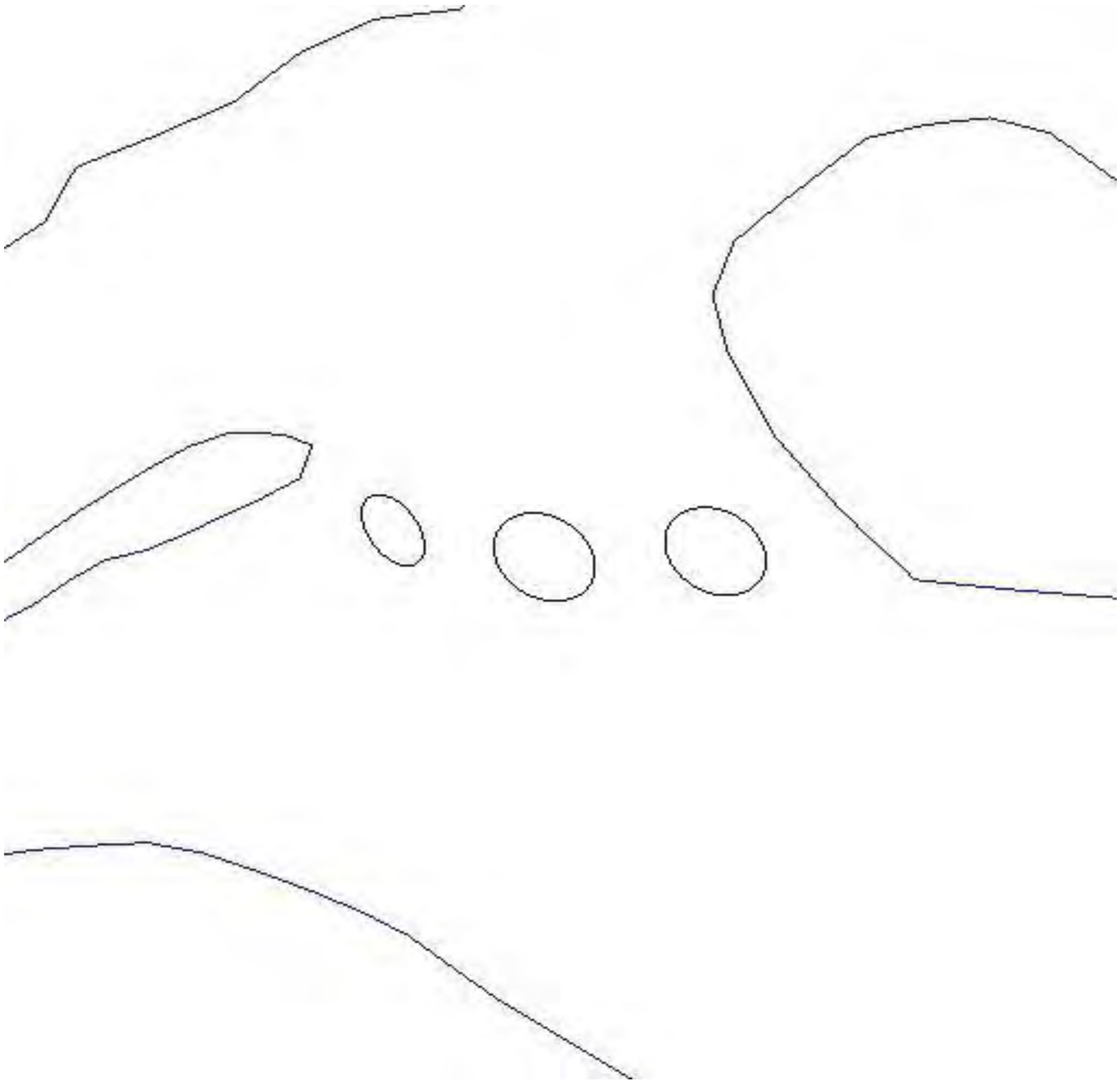

Figure 43. Proposed Mill Cove island alignment for Scenario 2.

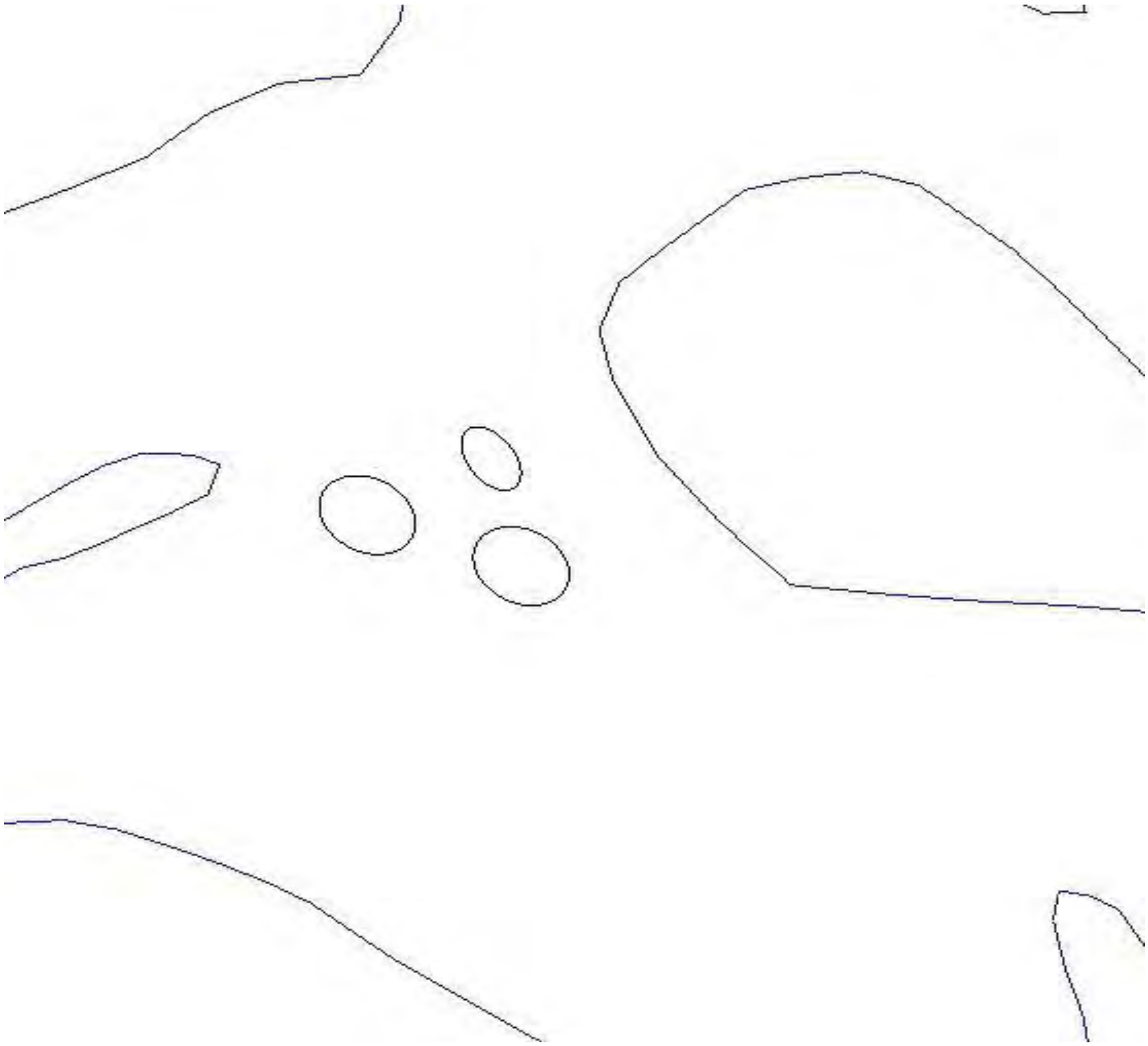

Figure 44. Proposed Mill Cove island alignment for Scenario3.

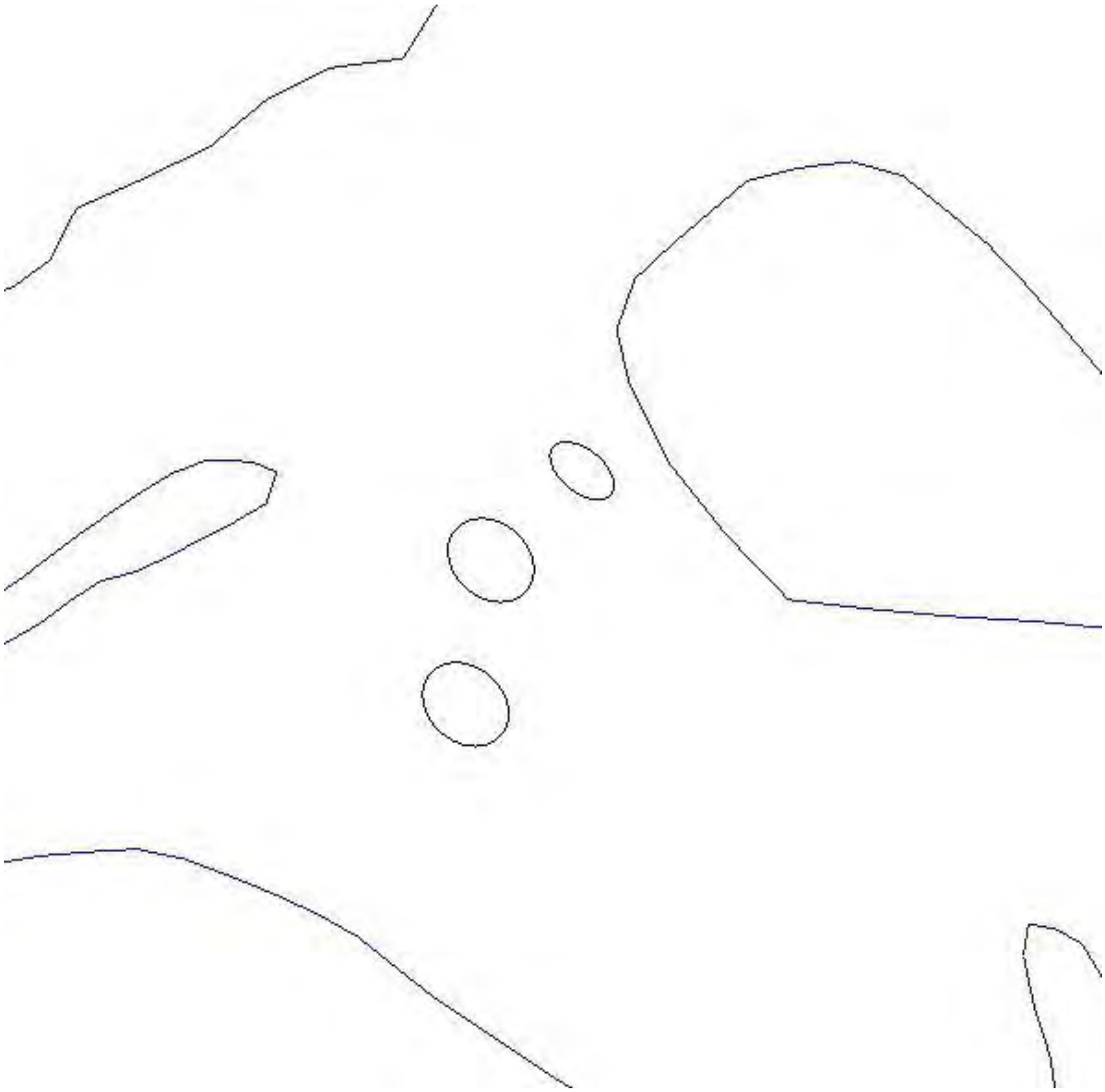

Figure 45. Proposed Mill Cove island alignment for Scenario 4.

The mesh for the Jacksonville Harbor AdH model was modified to include the islands in the Mill Cove area as shown in Figure 46. The islands in the model mesh are represented as different material zones, which can be turned off to exclude them as inactive zones while running the model. The modeling analysis includes the 46-ft deepening alternative under consideration in the Jacksonville Harbor GRR2 for all simulations. The scenarios were run with tidal boundary conditions for the month of June 2009.

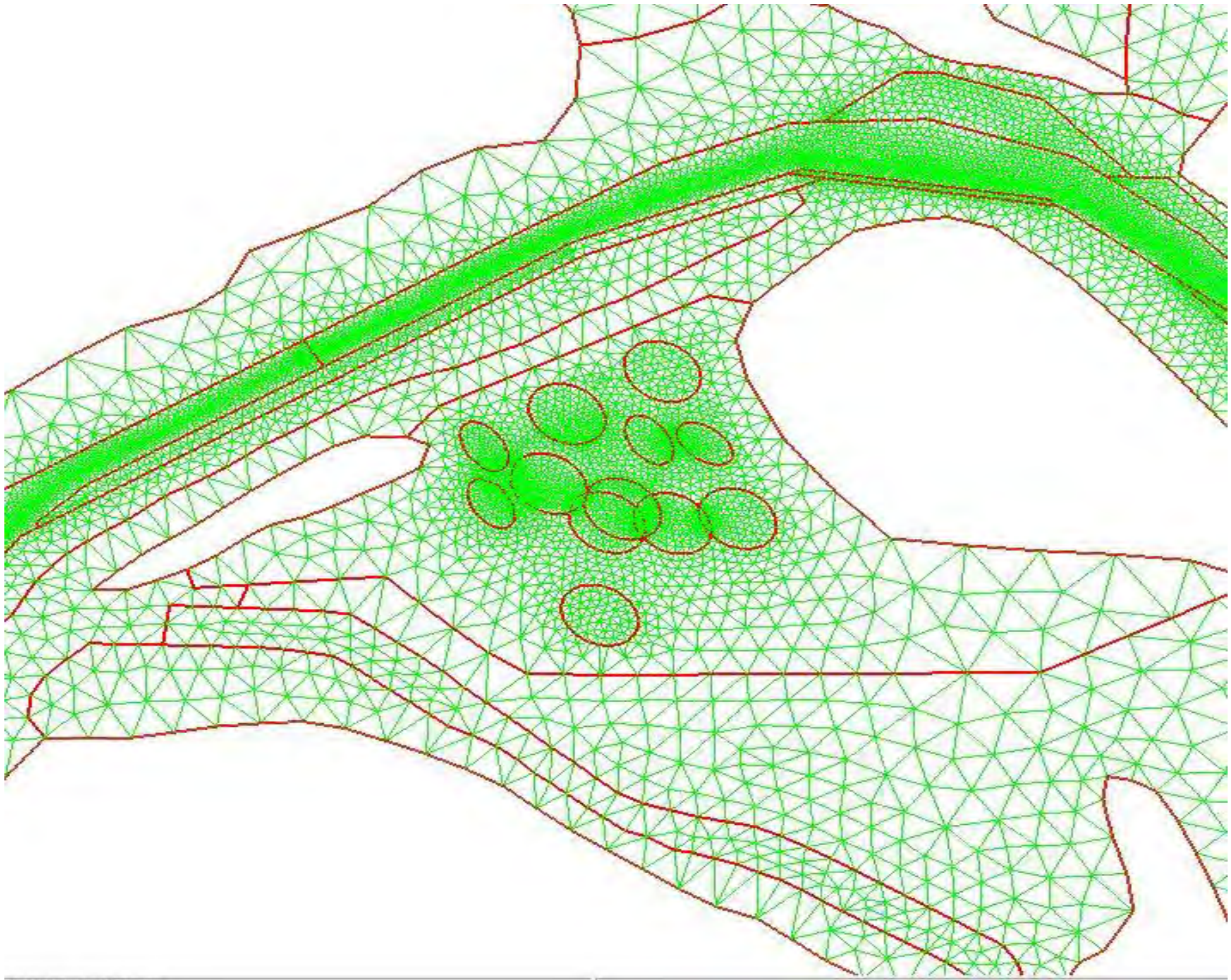

Figure 46. Proposed Mill Cove islands within the Jacksonville Harbor AdH model mesh.

Of the four scenarios, only the model results for Scenario 3 have been post-processed and compared with the existing condition (No Disposal Islands). Figure 47 shows the location of three points selected to compare the water surface elevations and velocities between Scenario 3 and the existing condition. The water surface elevations at points one, two, and three are shown in Figures 48, 49, and 50, respectively. As shown in the plots, there are no significant changes in the water levels. This result is very intuitive considering that there are multiple openings for flow into and out of Mill Cove and any reduction in flow caused by the islands would be accompanied by an increase in flow at one of the other openings.

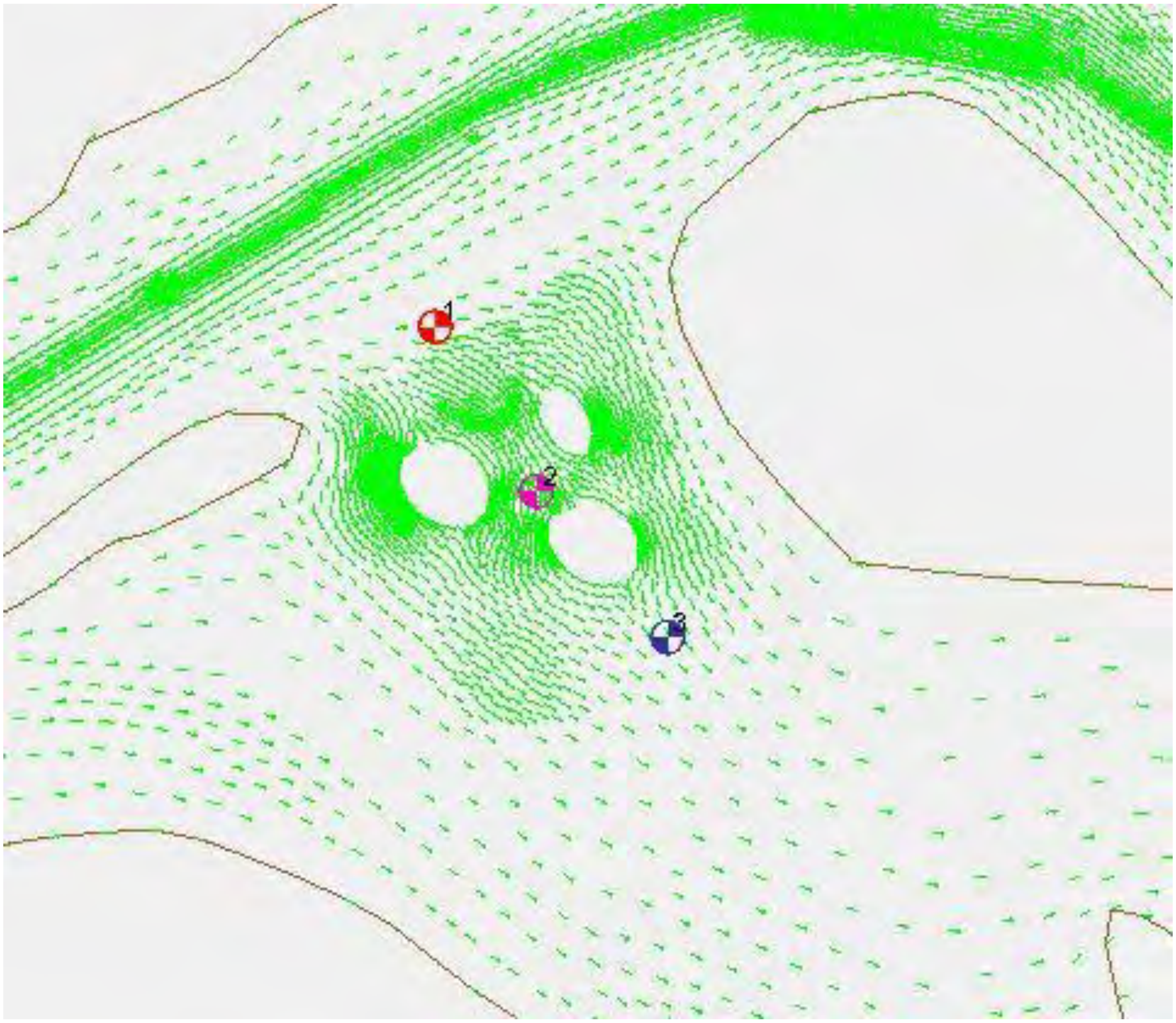

Figure 47. Location of points for water surface elevations and velocities.

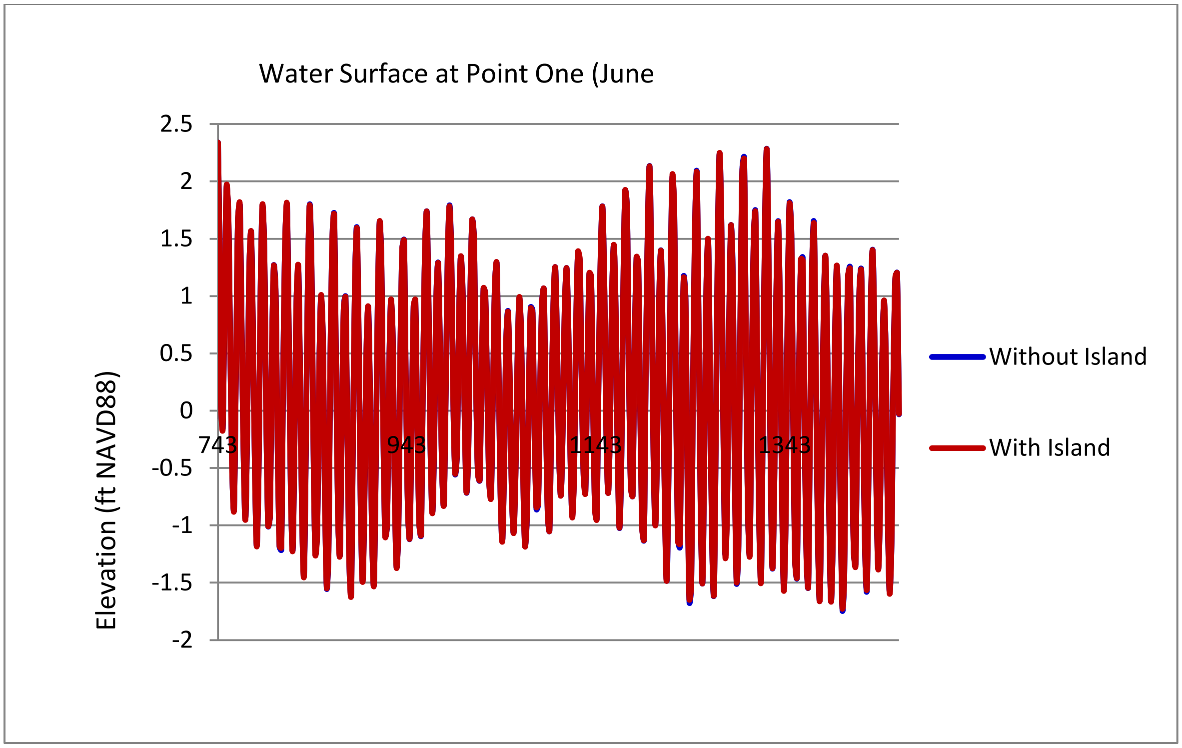

Figure 48. Water surface elevation at point 1.

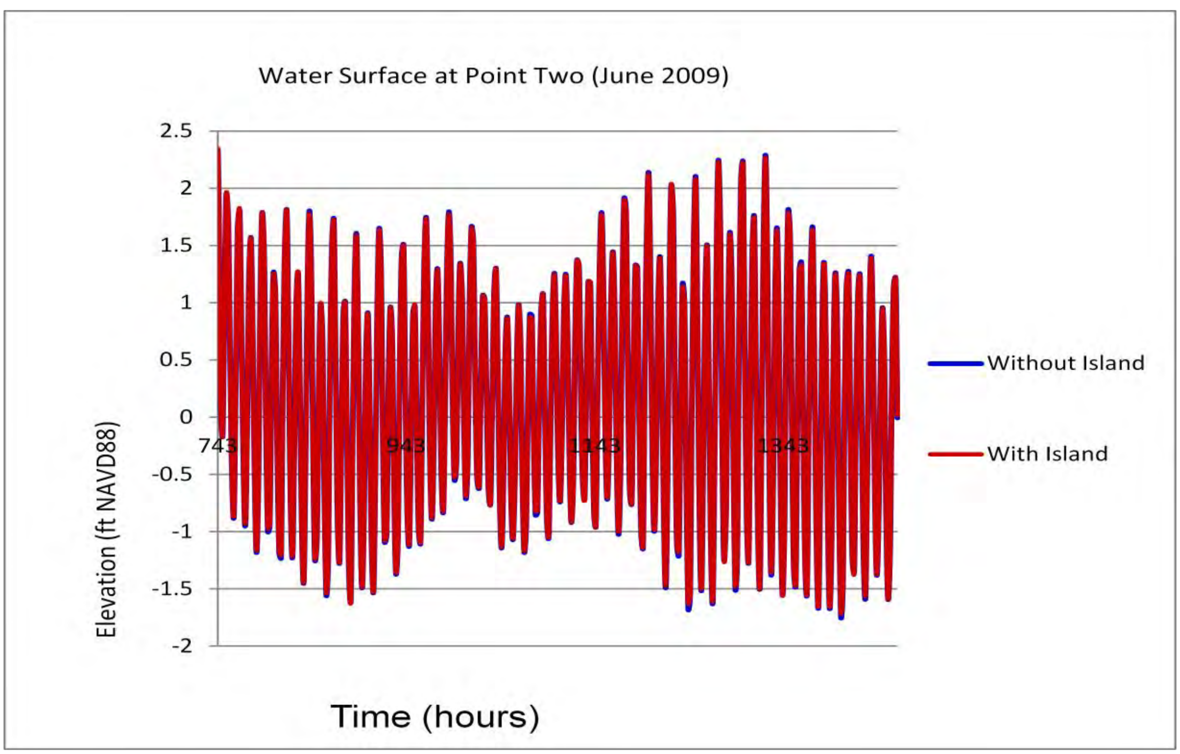

Figure 49. Water surface elevation at point 2.

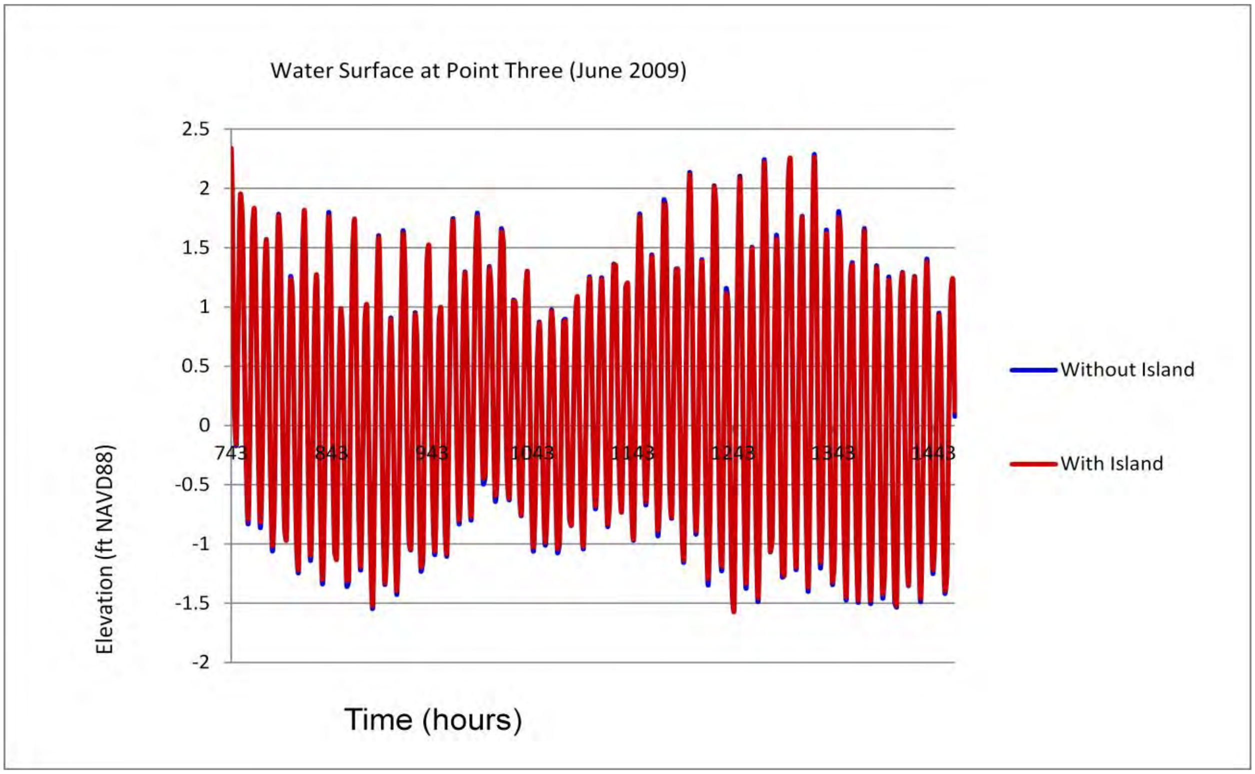

Figure 50. Water surface elevation at point 3.

The comparisons of velocities at the three points are shown in Figures 51, 52, and 53. While the velocities at Point 1 are unchanged, the middle point (Point 2) and the point south of the islands (Point 3) show decreases in peak velocities of approximately 0.1 to 0.15 feet per second.

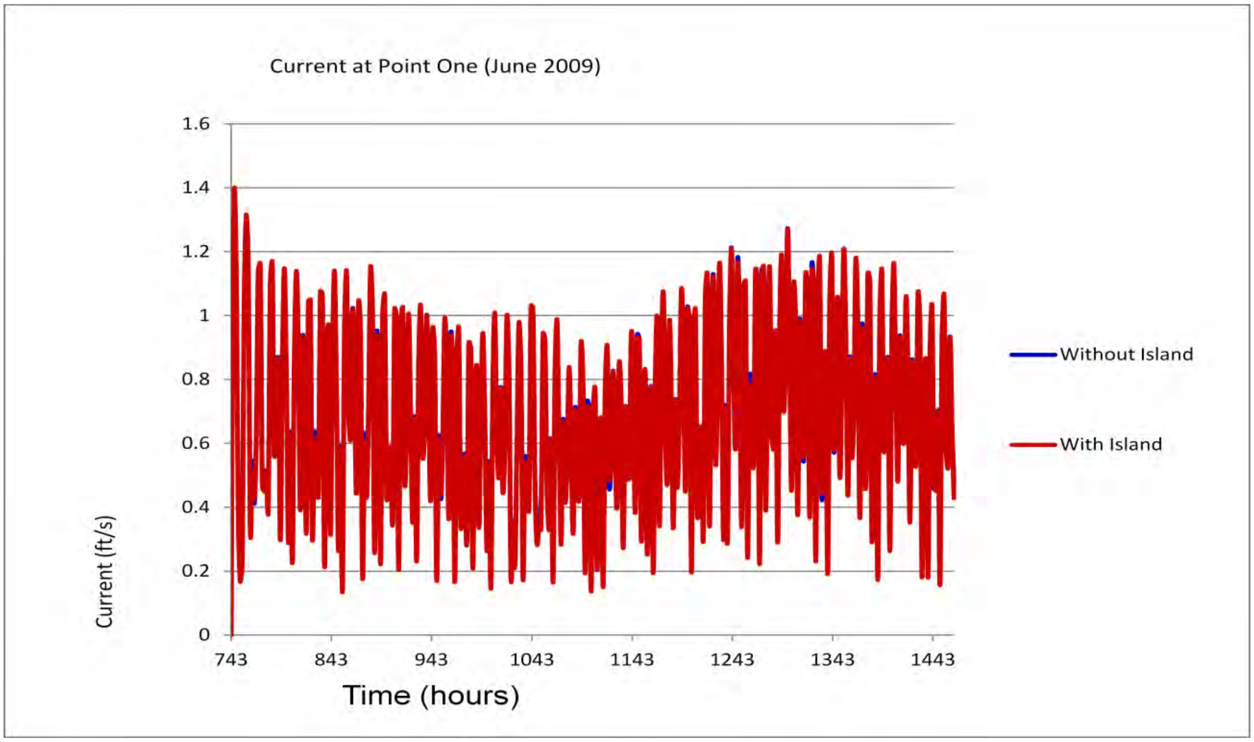

Figure 51. Water velocity at Point 1.

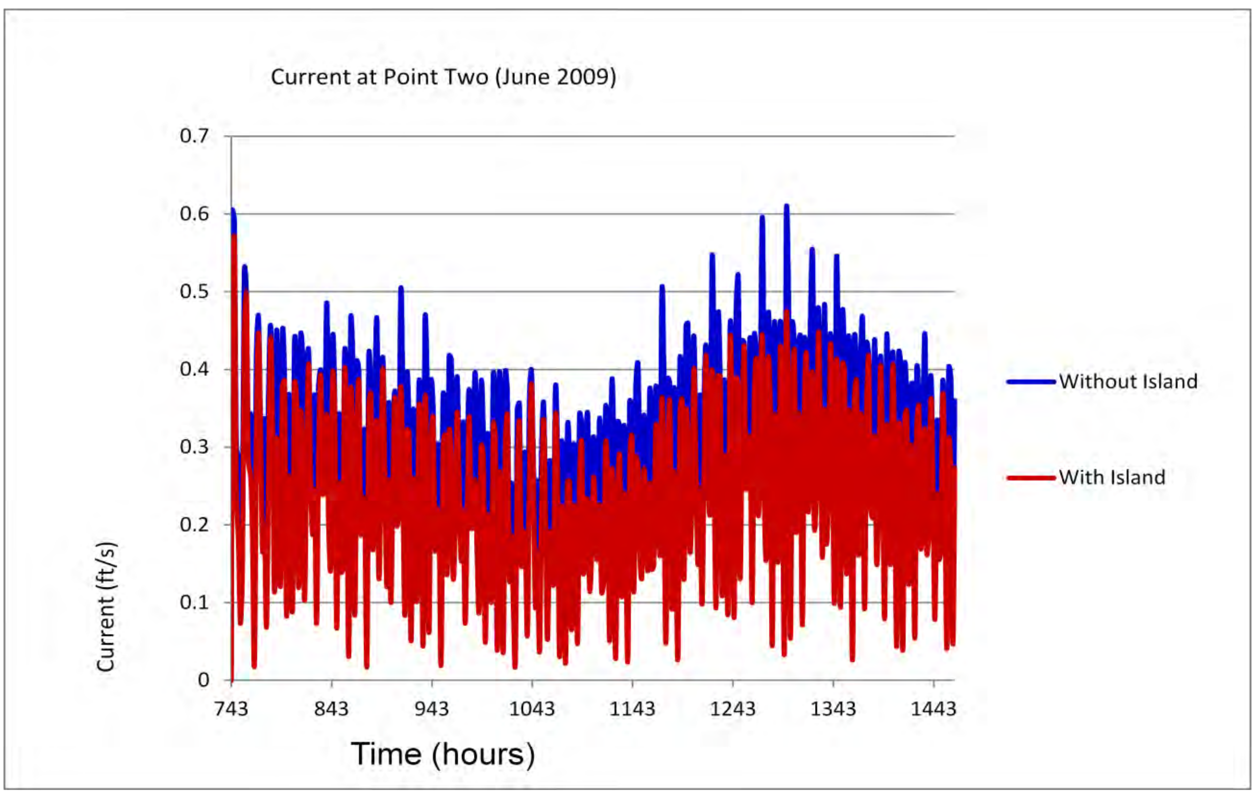

Figure 52. Water velocity at point 2.

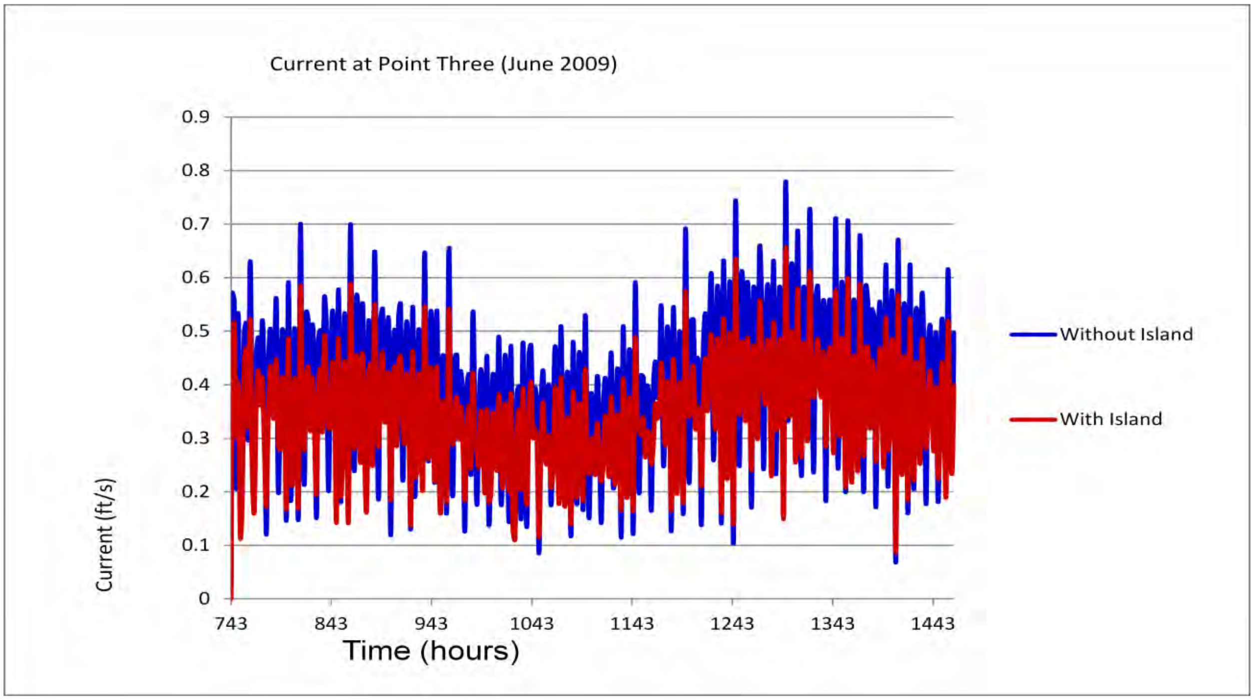

Figure 53. Water velocity at point 3.

The model results were also processed to show the total flow across the transect lines near the islands (see transect locations 1-5 in Figure 54). The flow rates through these transects are shown in Figures 55 through 59. Due to the obstruction caused by the islands along the flow-way, the flow rates through transects one (Figure 55), four (Figure 58), and five (Figure 59) decrease. However, as previously noted and as demonstrated by the results for Transect 2 (Figure 56) and Transect 3 (Figure 57), these decreases in flow near the islands are accompanied by increases in flow elsewhere.

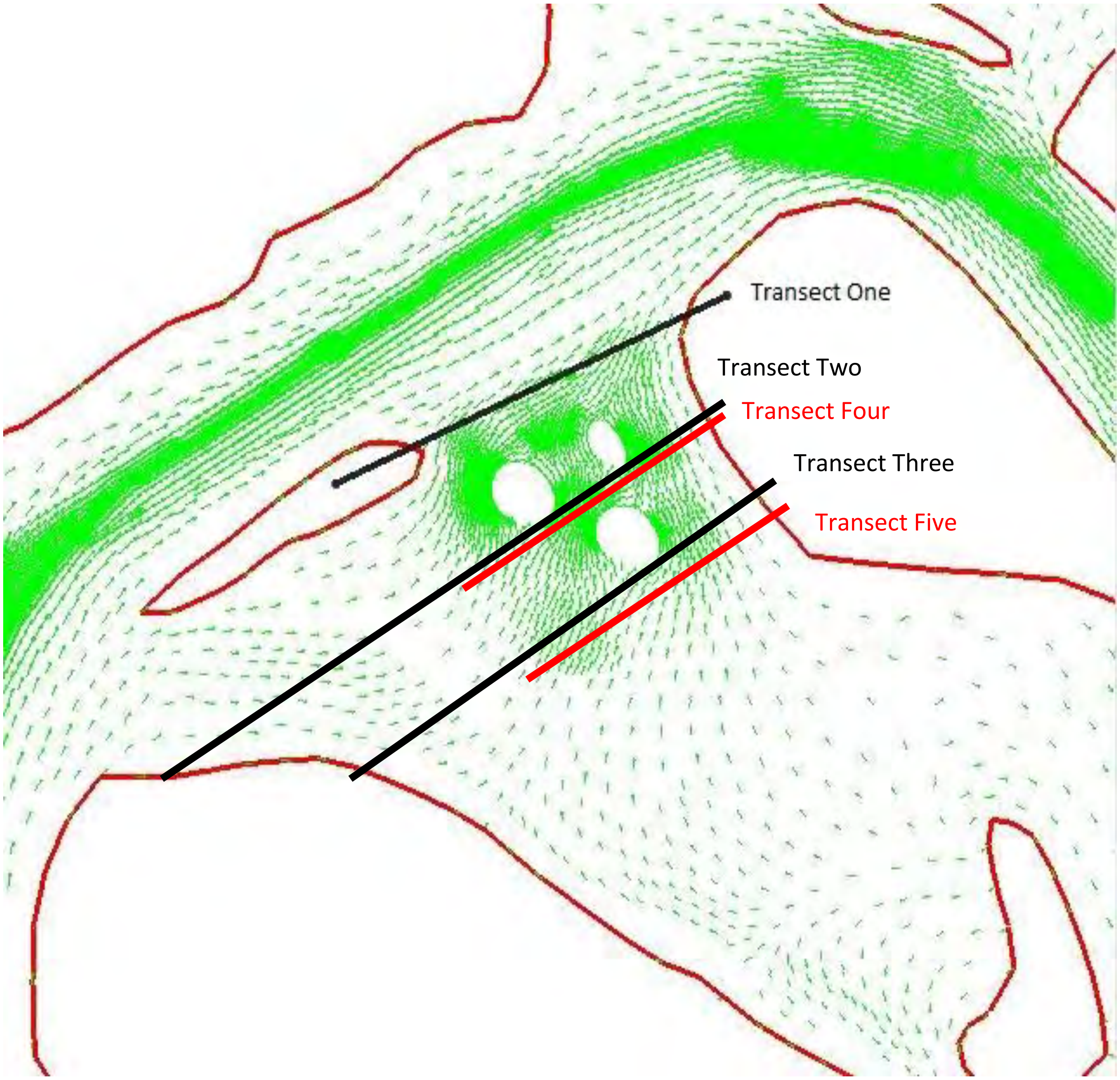

Figure 54. Flow transect line locations.

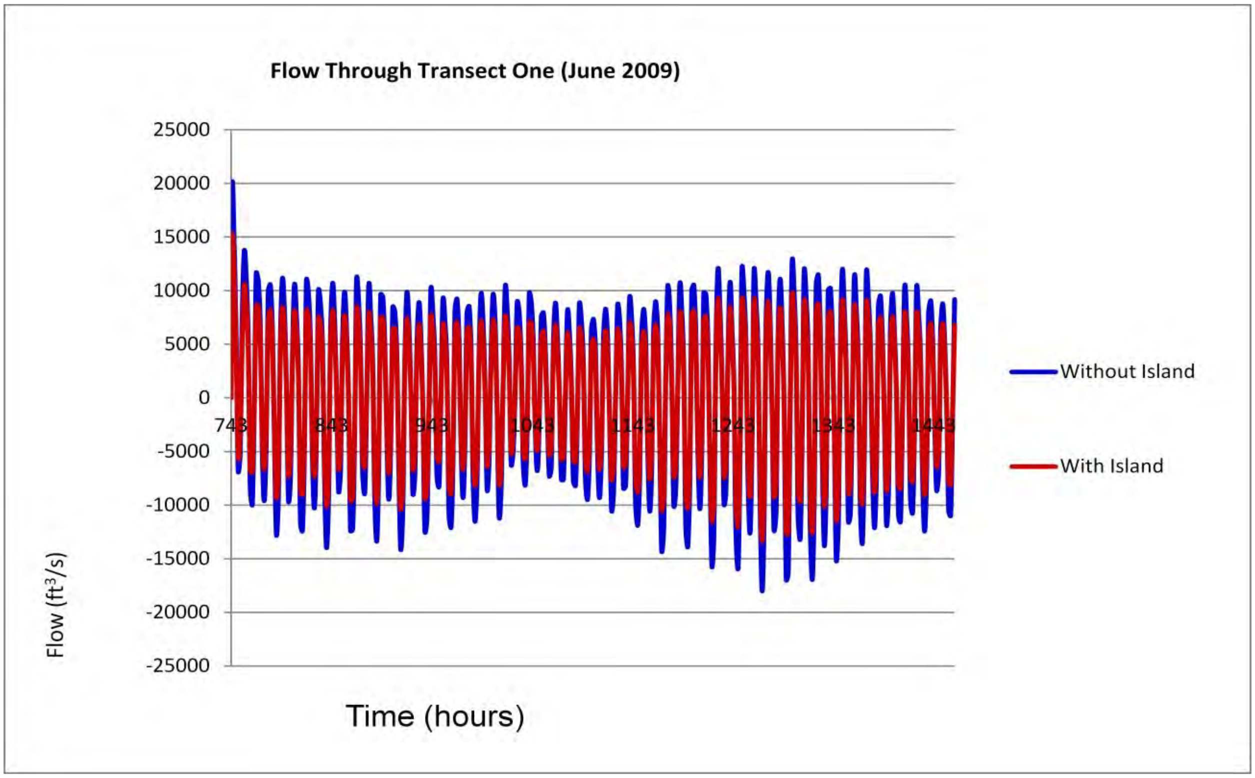

Figure 55. Total flow across transect line 1

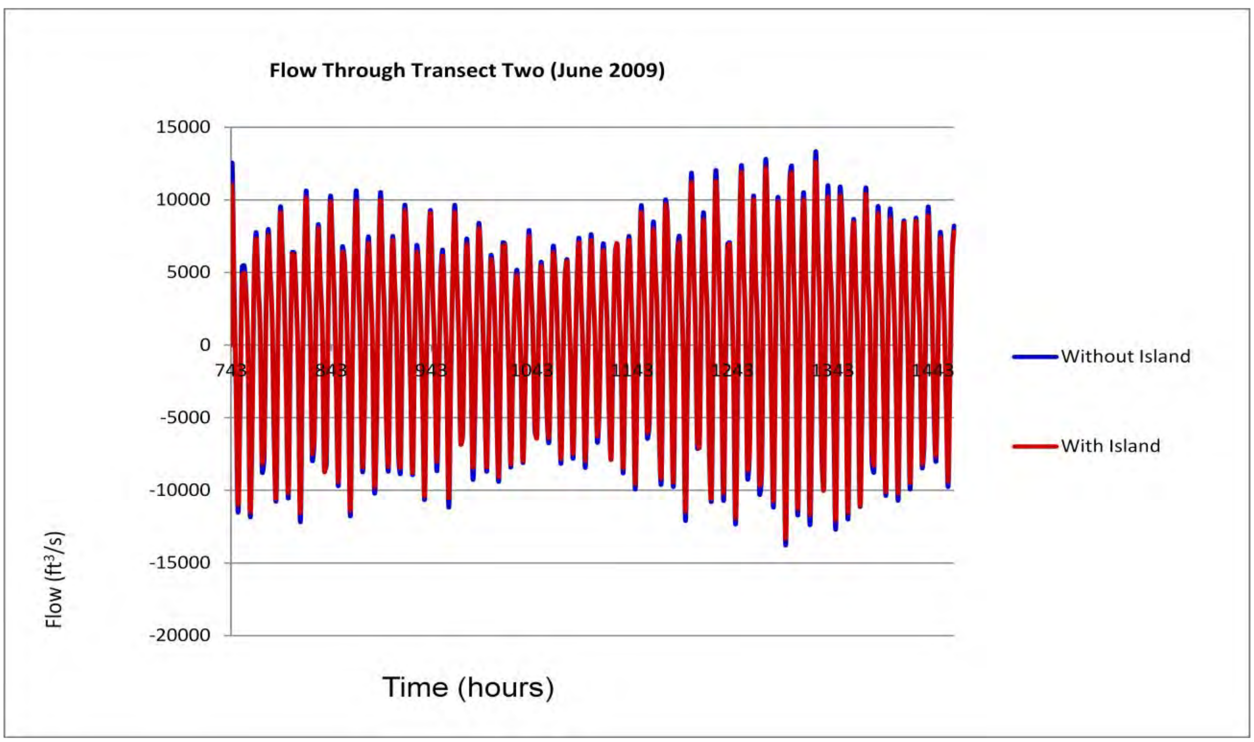

Figure 56. Total flow across transect line 2.

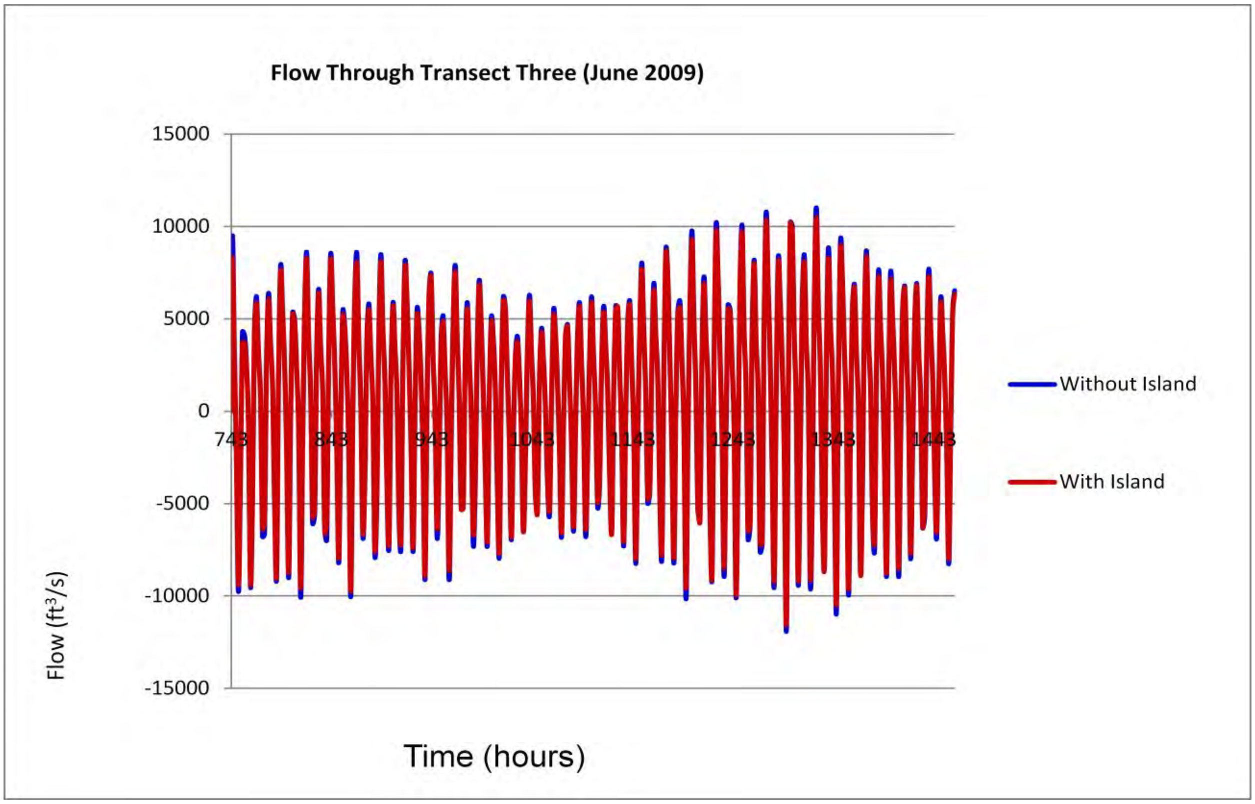

Figure 57. Total flow across transect line 3.

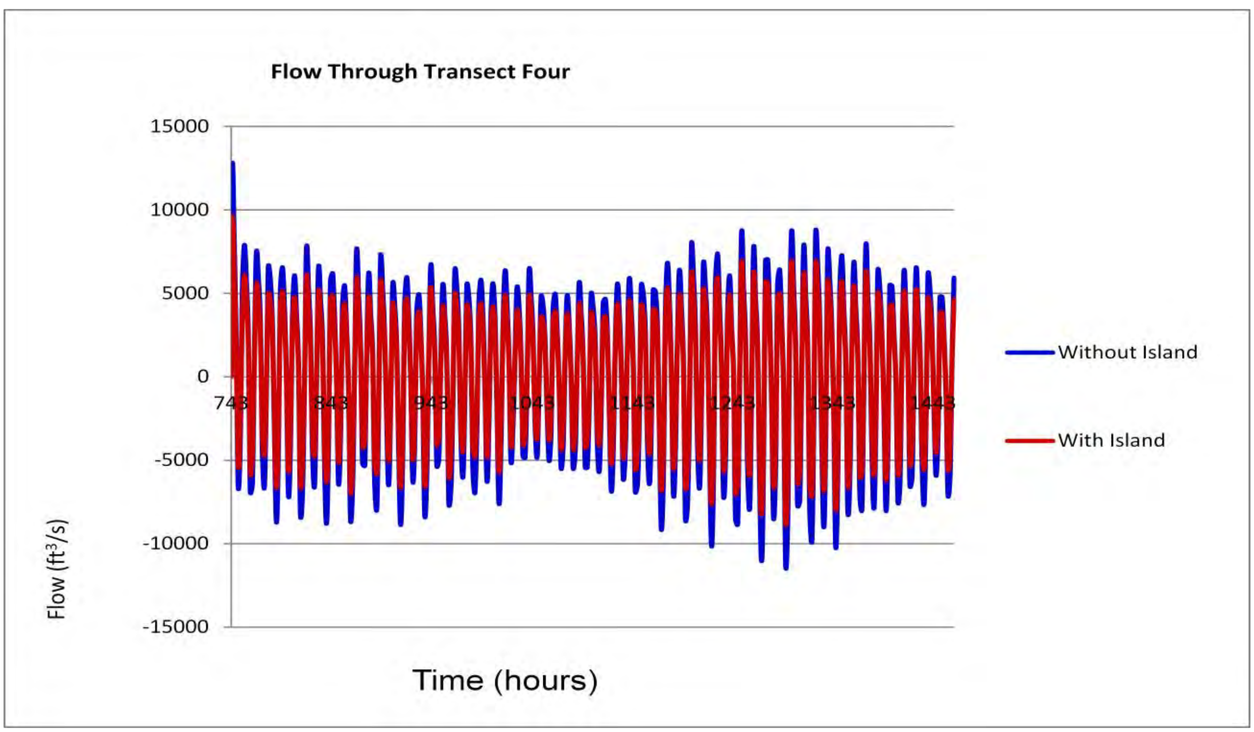

Figure 58. Total flow across transect line 4.

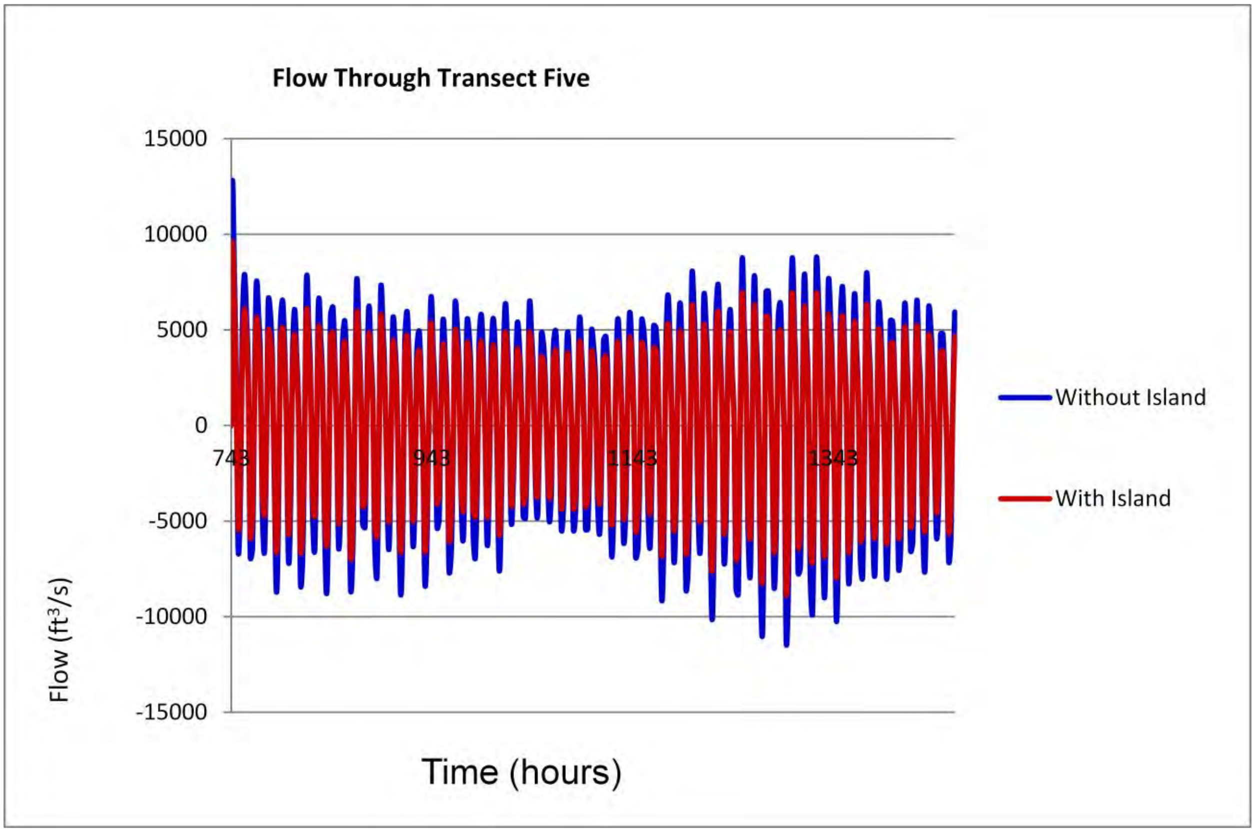

Figure 59. Total flow across transect line 5.

The creation of the islands within Mill Cove will have no significant effects on the water levels and the volumes of water flowing into and out of Mill Cove. However, as noted above, very slight reductions in water velocities can be expected to occur in the immediate vicinity of the islands, accompanied by very slight increases in velocity at other locations. While the velocity differences are minimal, it should be noted that Mill Cove is a very shallow water body which currently experiences shoaling. While specific changes in sedimentation rates are beyond the scope of this modeling effort, it is reasonable to infer that slight changes in sedimentation rates and patterns could occur, potentially increasing in locations near the islands, while decreasing near the other openings to Mill Cove. It is also possible that, over time, as sediment may accumulate around the proposed islands, the flow at the other outlets could become more channelized, changing those local environments. This increased channelized flow could also potentially scour or entrain flocculent material, or silt, which could pose potential HTRW concerns.

9.0 ASSUMPTIONS AND LIMITATIONS

Several assumptions in the conceptual model were made before the construction of the AdH model for the Jacksonville Harbor. The assumptions were necessary to bridge the gap between the available data and the requirements of the numerical model. Spatially variable roughness coefficients were used and adjusted to ensure proper predictions and stability of the model. It was assumed that the roughness coefficients do not change during the period of simulations.

The effects of wind were not directly incorporated into the model by assigning the wind data. In the model, the tidal boundary conditions were assigned that included the effects of wind. Also, the calibration was performed against the measured data which included the wind effects.

The present hydrodynamic model for Jacksonville Harbor is represented by the two-dimensional form of the governing Navier-Stokes equations that are solved in the AdH modeling code. The hydraulic and hydrodynamic characteristics used in the model represent a vertically homogeneous system. It is a reasonable approximation considering the data availability and the complexities (computer resources and computational time) involved in a three-dimensional representation for an area and model domain of this large size.

The sediment transport model entails inclusion of complex processes. This can cause non-convergence of the solutions of the governing equations. Some simplifications were employed to overcome the instability in the AdH model. To ensure stability, the sediment class silt/clay was modeled as fine sand. In addition, the temporally constant eddy viscosities were used to ensure the stability of the model.

10.0 SUMMARY

A high-resolution hydrodynamic model was developed to simulate the tidal cycle in the domain under Jacksonville Harbor. It was observed that the model performed reasonably well in simulating the temporally and spatially varying tidal fluctuations and currents from the Atlantic Ocean to the St. Johns River.

The success of the model can be traced to its ability to represent spatially varying characteristics (roughness coefficient and eddy viscosity), time-varying boundary conditions, and wetting-drying processes in an irregular network of finite elements. Because of the tidal hydrodynamics, the water levels and the currents change in the channel. The driving forces including inflow and tidal fluctuations at the boundaries helped generate the results by the model for pre- and post-dredging conditions.

A reasonably good calibration of the AdH model for Jacksonville Harbor was performed by comparing with the observed data from June 16, 2009 at 3:00 pm to June 19, 2009 at 3:00 pm. The calibrated model was validated successfully using the tidal boundary condition data from

June 26, 2009 at 12:00 am to June 29, 2009 at 12:00 am. The simulated results for both water levels and currents were agreeable compared to the observed data. It is observed that the simulated current speeds are strong in the entrance channel near the shore line. After the successful calibration and validation, the AdH model for Jacksonville Harbor was used to simulate the alternatives for ship simulations. The simulated and depth-averaged current velocities for the existing condition and for the seven alternatives were later used for ship simulation.

The AdH sediment transport model simulated the bed level changes for both existing and with-project (46-ft depth) conditions. Based on the simulations, the shoaling rates and volumes were computed because of the dredging and widening of the channel. The with-project condition results in an increase in shoaling volume by approximately fifteen percent over the dredging sections 1, 2 and 3A.

The AdH hydrodynamic model for Jacksonville Harbor was used to investigate the effects of creating islands as a beneficial use of dredged material in Mill Cove. No significant effect on water levels and volumes of water flowing into and out of Mill Cove was observed by examining the model results. Slight reductions in water velocities can be expected to occur in the immediate vicinity of the islands. In addition, changes in sedimentation rates and patterns could occur in locations near the islands.

11.0 REFERENCES

Berger, C, and J. Tate, 2007. Guidelines for Solving Two Dimensional Shallow Water Problems with the Adaptive Hydraulics (AdH) Modeling System. USACE ERDC.

USACE-SAJ, 2007. Jacksonville Harbor General Reevaluation Report 2 (GRR 2). Feasibility Scoping Meeting Documentation. Jacksonville District.

DRAFT

NAVIGATION STUDY FOR
JACKSONVILLE HARBOR, FLORIDA

DRAFT INTEGRATED GENERAL REEVALUATION REPORT II
AND
SUPPLEMENTAL ENVIRONMENTAL IMPACT STATEMENT

APPENDIX A
ATTACHMENT H

ENGINEERING – CMS Hydrodynamic Modeling for Coastal Processes and Channel Shoaling

Table of Contents

**COASTAL MODELING ATTACHMENT
JACKSONVILLE HARBOR NAVIGATION STUDY, DUVAL COUNTY, FLORIDA**

INTRODUCTION

Background

This General Reevaluation Report (GRR) is being prepared to determine the feasibility of deepening and/or widening the federal navigation channel of the Jacksonville Harbor Federal Navigation Project. Alternatives being considered include the deepening of the Federal Channel over the lower 14 miles of the St Johns River, widening along the Trout River Cut Range, Short Cut Turn, and Training Wall Reach areas.Installation of a training wall along the Mile Point Reach is anticipated to be completed prior to implementation of the Jax Harbor GRR2 project and was therefore treated as a future without project condition in the study.
.

The followinganalyses of the coastal processes in the vicinity of the St Johns River entrance provide a basis for evaluating the sediment transport and shoaling characteristics in the Federal navigation channel in the vicinity of the jetties. This work provides a baseline for evaluating the impacts of channel deepening to the adjacent beaches. A coastal process analysis of the St Johns River entrance was conducted, including historical shoaling estimates based on historical bathymetry surveys of the channel and adjacent areas and application of the Coastal Modeling System (CMS).

Currents, waves, sediment transport, and morphology at the St Johns River Entrance form a coupled dynamic system. This complex system dictates the transport of littoral sediment into and out of the navigation channel and to or from adjacent beaches. In order to determine the pathways and transport rates in this inlet system, CMS was used to simulate historical morphologic changes. This attachment presents the modeling results of recent changes to the inlet system that occurred when the entrance channel was deepened to a 50 ft MLLW project depth in 2012 by the Navy. Additional analyses are planned for the Jacksonville Harbor GRR2 modifications to the inlet system.

Figure 1. Jacksonville Harbor coastal navigation study area.

Objectives

The objectives of these analyses are twofold: primarily, to understand the potential of increased shoaling in the navigation channel due to Harbor deepening; and secondarily, to identify changes to the nearshore coastal processes and subsequent impact, if any, to adjacent beaches. An initial assessment of sediment transport pathways and shoaling patterns and rates was conducted to address the impact of historical deepening to adjacent beaches and channel shoaling. The preliminary analysis included the review of all available data and prior reports to determine historical relationships between harbor deepening and shoreline position and volume changes extending up to 10 miles north and south of the Jacksonville Harbor entrance channel. This historical relationship was then utilized to ascertain the potential increase in impacts due to an enlarged channel with resultant increases in tidal prism, tidal current velocity, littoral barrier effects, and ebb and flood shoal alterations.

In addition, a coastal processes model (CMS) was used to simulate combined current, wave, and sediment transport processes in the study area. Relating results of the coastal process model with historical change immediately furthers the understanding of nearshore processes in the region. In addition, the model is used as a means to predict the impact of Harbor deepening on the spatial and temporal extent of shoaling in the navigation channel as well as the impact on adjacent beaches to the north and south of the St. Johns River entrance.

Options to mitigate against impact, if any, to adjacent beaches which can be attributed as a direct result of harbor deepening will also be evaluated. Nearshore or beach placement options will be evaluated by the following guidelines:

(a) Regional Sediment Management. Regional sediment management (RSM) principles and guidelines will be addressed to specify the placement of beach quality material excavated during construction and maintenance dredging activities at Jacksonville Harbor on the area's adjacent beaches.

(b) Beach Placement. The analysis will include designated placement reaches and fill templates as appropriate and the integration of these operations with other similar activities which impact beach nourishment operations within the northeast Florida region.

(c) Alternative Littoral Zone Placement. Existing available data and modeling studies will be reviewed and utilized to evaluate near-shore placement of excavated material with quality suitable for that purpose. The placement will be structured to provide positive impacts for the Duval County Shore Protection Project while also addressing the potential recreational benefits due to artificial surfing reef creation.

Technical Approach - Coastal Process Modeling

The technical criteria for selecting an appropriate hydrodynamic model that well represents the physics of the nearshore processes for the subtask presented in this attachment are based on the coastal forcing that affects sediment transport pathways, entrance channel shoaling, and shoreline change. The selected model should adequately capture those forcing conditions and determine the morphologic response due to sediment transport.

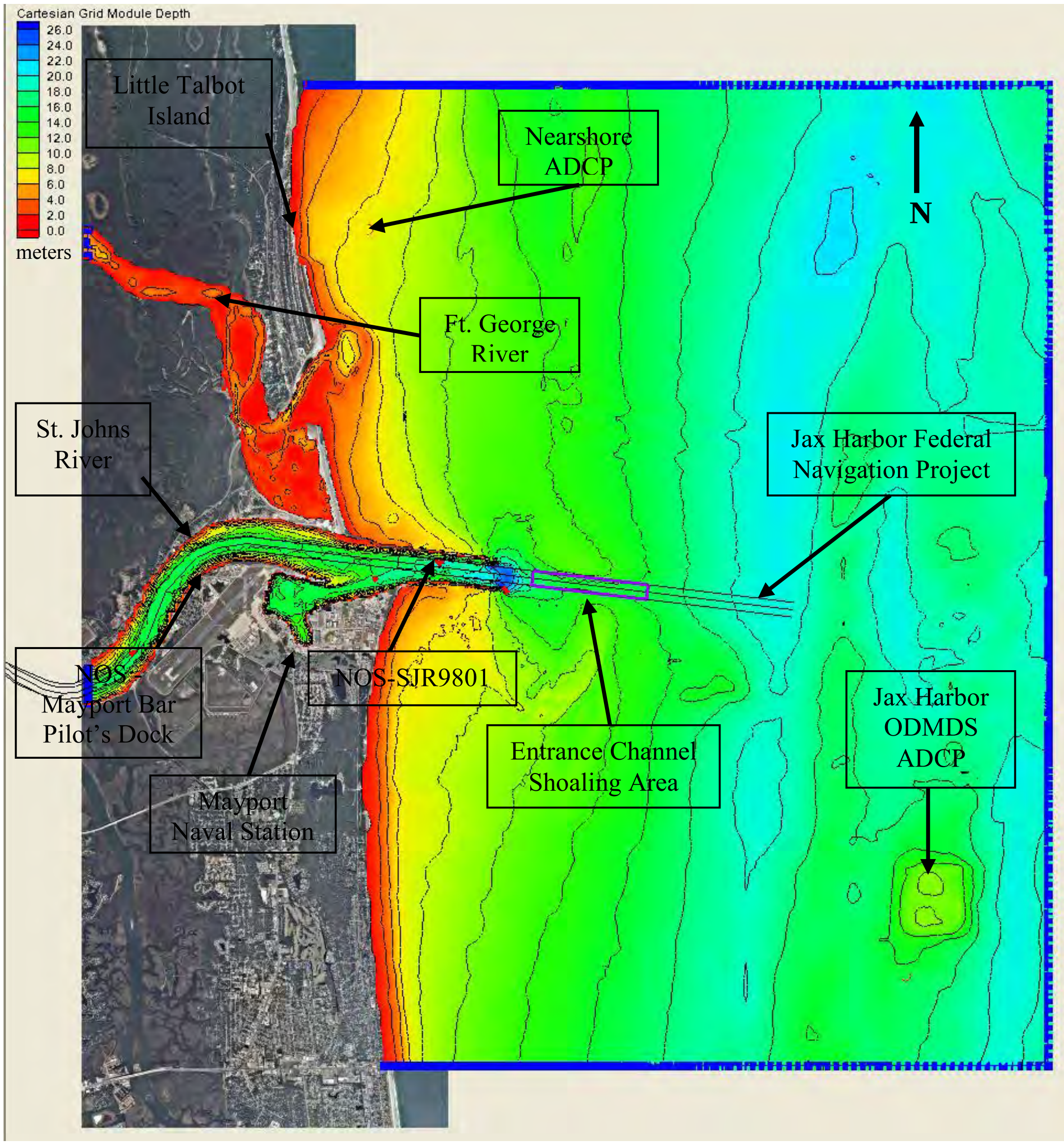

Figure 2. Jacksonville Harbor hydrodynamic model grid domain, bathymetry, and project features.

To represent the hydrodynamics and sediment transport of the Jacksonville Harbor inlet system and the effect of recent and proposed engineering alternatives on wave action and circulation, the Coastal Inlets Research Program (CIRP) Coastal Modeling System (CMS) (Sanchez, et.al. 2011) models were applied.

CMS is an integrated two-dimensional (2-D) numerical modeling package for simulating waves, current, water level, sediment transport, and morphology change at coastal inlets and entrances. For this project, the numerical wave and circulation models, CMS-WAVE and CMS-FLOW, respectively, were run in a coupled mode with information passed between the models at specified intervals. Of primary interest is the use of the CMS model to determine sediment exchange between the ebb shoal and navigation channel. Secondary interests include the understanding of changes in wave fields, flow circulation and sedimentation patterns as a result of the Mayport deepening project. Currently only the effects of the Mayport deepening have been investigated, as reported in this attachment. However, the proposed changes included in the Jacksonville Harbor GRR2 selected plan are not expected to significantly impact the shoaling rates in the entrance channel when compared to the effects of the Mayport deepening. This hypothesis will be tested as a part of future work.

Future Jacksonville Harbor Conditions

The existing authorized civil works entrance channel is 800 ft wide and 42 ft MLLW (12.8m) deep (see Figure 2). The US Navy (USN) has deepened the entrance channel, known as Bar Cut 3, through the inside of the jetties to the Mayport Basin entrance channel, to a project depth of 50 ft MLLW. The Jacksonville Harbor GRR2 project alternatives under consideration include: widening the channel varying amounts (up to 300 ft) starting about 1.0 mi east of the Atlantic Intercoastal Waterway (AIWW) and extending about 4.8 mi up river; deepening the inner channel to the Locally Preferred Plan (LPP) depth of 47 ft MLLW for the majority of the project; deepening the entrance channel to 49 ft MLLW (LPP plan); providing advanced maintenance dredge areas equal to 2 ft for existing shoaling areas or anticipated shoal areas; and providing turning basins adjacent to Blount Island and Brills Cut (see Figure X, Appendix A).

Preliminary Historic Shoaling Analysis

The pilot study by Thomas and Dunkin (2012) developed a method to utilize both historical dredging records as well as recent survey data to estimate annual shoaling rates for the USN facility at Mayport. The historical dredging records are presented in .The study estimated shoaling rates prior to the Navy's 2012 dredging event which deepened project depths to 50 ft MLLW, as well as projected rates five years into the future. Using the dredge history data, the annual requirement for the entrance channel (Bar Cut 3) equaled 141,000 cubic yards per year (cy/yr); using the recent surveys of the channel, the annual estimate equaled 165,000 cy/yr. The analysis weighted each estimate based on the reliability of the data and applied a weighting factor of 0.4 to the historic dredge estimate and 0.6 to the estimate from the survey analysis. The final pre-deepening estimate therefore equaled 155,300 cy/yr.

Table 1. Contract date and quantity of material dredged from NS Mayport.

Dredging Contract End Date	Volume Dredged, Cu yds
1/6/1954	346,312
8/1/1956	897,777
10/19/1959	1,411,640
9/1/1961	1,373,350*
10/20/1962	559,092
1/1/1964	289,050
3/1/1965	1,962,067
12/1/1966	868,479
3/10/1969	716,858

9/1/1969	441,323
8/4/1972	570,972
3/25/1974	547,565
2/1/1975	736,084
3/1/1978	1,789,701
10/24/1978	173,558
7/5/1979	47,148
3/1/1982	1,793,031
8/19/1983	81,363
11/19/1983	48,000
8/24/1984	223,000
6/1/1985	1,280,151
1/1/1990	1,600,135
5/29/1993	27,680
5/21/1994	1,230,507
1/29/1997	1,099,371
3/27/2000	1,097,800
10/22/2001	174,832
4/24/2003	1,289,138
1/1/2005	1,069,754
5/19/2008	629,034
1/30/2010	174,941
4/16/2012	4,552,000*
* Includes new work dredging.	

(Thomas and Dunkin, 2012)

In order to account for the 2012 deepening to 50 ft MLLW, the Thomas and Dunkin (2012) estimate added an additional 2% to the annual rate, which was the amount of shoaling rate increase in the entrance channel predicted by NAVFAC (2008). So the yearly shoaling estimate for the entrance channel equaled 158,400 cy/yr. The estimated five year dredging requirement was therefore equal to 792,000 cy. The skill of the model used in the NAVFAC (2008) analysis was noted to be relatively poor at analyzing non-cohesive sediments, the major constituent in the entrance channel. Thomas and Dunkin (2012) mention that the value of 2% for the increase in shoaling rates is not consistent with previous observations after a deepening event in locations with relatively high shoaling rates and expect actual rates to be higher.

Baseline Shoaling Analysis

The USN Mayport deepening project which was completed in 2012 had the potential to significantly change shoaling rates at the channel entrance. For this study it is therefore established that the 2012 entrance channel configuration is the ***new baseline*** and is included in the future without project condition, from which comparison will be made with future Jacksonville Harbor GRR2 project alternatives. The shoaling rate for the

Mayport deepening, which is an existing condition for the Jacksonville Harbor deepening project, will be based on CMS modeling and the results of Thomas and Dunkin (2012).

HYDRODYNAMIC MODEL APPLICATION

Coastal Process Model Setup

<u>Numerical Grid Development</u>

A variable rectilinear grid was used to accurately and efficiently represent the hydrodynamics of the St. Johns River Entrance prior to and following the USN deepening to a project depth of 50 ft MLLW. Three model grids were created to complete the effort: a “parent” CMS Wave Grid (CMS-WG), a (“child”) Nested CMS Wave Grid (NCMS-WG), and a CMS Flow Grid (CMS-FG) that utilized the same spatial domain and cell sizes as NCMS-WG. Since NCMS-WG and CMS-FG require high resolution to resolve the hydrodynamics of the inlet system, CMS-WG was created to transform measured deepwater waves from the buoy measurement location (about 40 miles offshore) into the seaward boundary of the nested wave grid. Figure 3 shows the CMS-WG and the seven nested output locations for passing wave data to NCMS-WG, shown in Figure 4.

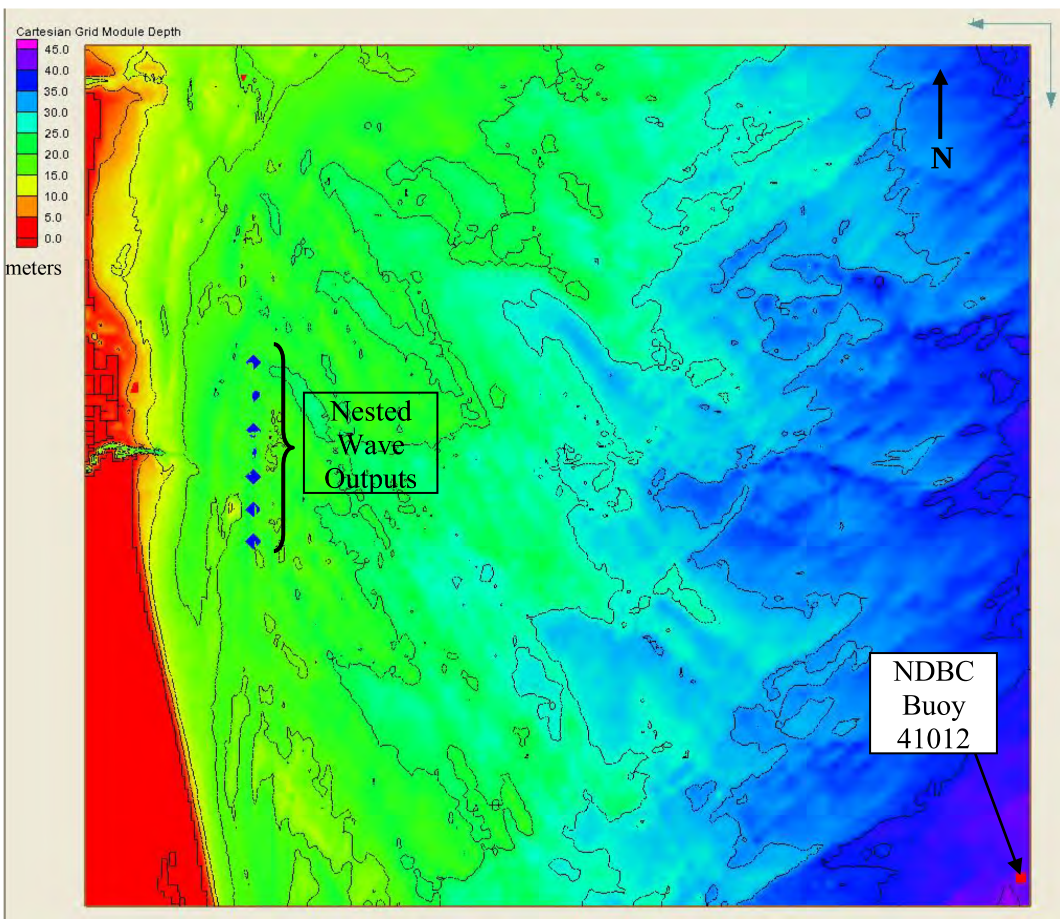

Figure 3. CMS-Wave parent grid.

The CMS-WG consists of a variable rectilinear grid with 29,952 cells. Cell size ranges from 299 ft (91 m) on a side just landward of the nested output locations to 1,968 ft

(600 m) at the north and south limits of the grid. At the nested output locations, minimum cell sizes were about 361 ft (110 m) by 325 ft (99 m). The cell sizes were reduced through use of refine points whose spacing decreased moving toward the shoreline. This spacing provides increasing resolution as wave shoaling effects increase due to decreasing water depths. CMS-WG extends 50.0 mi along the coast and 55.0 mi in the cross shore direction.

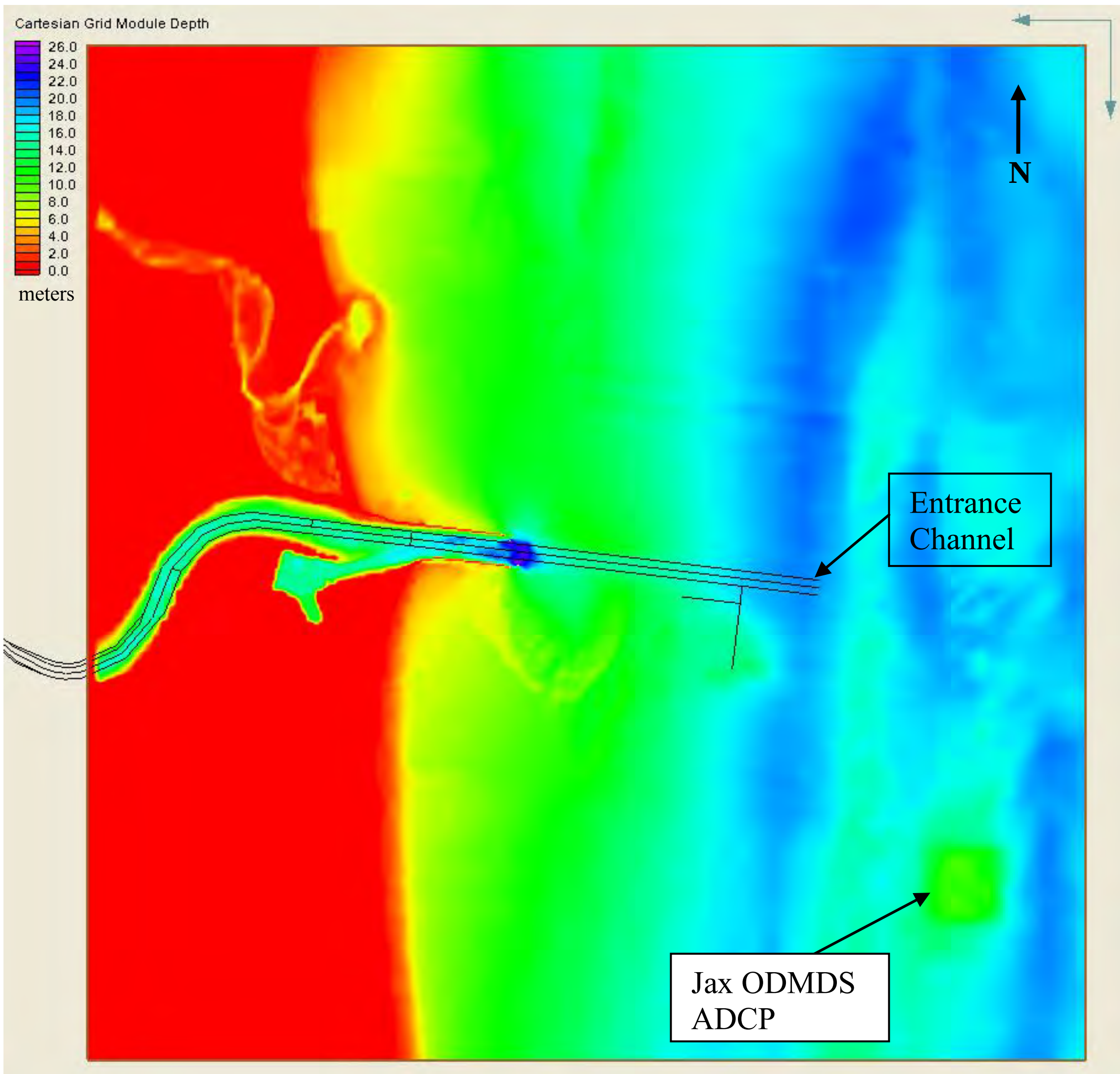

Figure 4. CMS-Wave nested grid with entrance channel alignment.

The existing Federal entrance channel is 800 ft wide and 42 ft MLLW (12.2 m) deep (project depth), and the proposed locally preferred alternative plan (LPP) increases the Federal entrance channel project depth to 49 ft MLLW (14.3 m) deep. Note that future without project conditions include the recent deepening of the entrance channel to 50 ft MLLW (14.6 m) depth by the USN. In order to represent these modifications in a hydrodynamic model, the horizontal grid resolution must be fine enough to represent the width of the inlet with 12 or more cells.

The CMS-FLOW model grid consists of a variable rectilinear grid with 60,433 cells. Cell size ranges from 98 ft (30 m) on a side within the navigation channel area to 492 ft (150 m) at the north and south limits of the grid. This resolution results in 15 grid cells between the jetties. Both the CMS-Flow and CMS-WAVE grids, shown in Figure 2 and Figure 4, extend 10.2 mi along the coast and 10.0 mi in the cross shore direction and were specified to have less than 492 ft (150 m) spacing over each domain. This spacing provides adequate resolution for sediment transport and shoal rate estimates.

Since the sediment transport within the riverine portion of the channel was modeled using the ADH hydrodynamic model (See Appendix A, Attachment C), the CMS-Flow domain only extends about 8.0 river-miles (13,000 m) west from the outer channel limits. The seaward edge was situated sufficiently far enough away from the inlet jet to negate the influence of the ebb tidal jet.

Bathymetry

Bathymetry for the hydrodynamic model is based on USACE surveys of the navigation channel and areas outside the jetty tips collected in 2009 as well as survey data compiled by the National Ocean Service (NOS). The CMS-WG additionally used data from the Coastal Relief Model (CRM), which is also largely composed of NOS datasets. The interactive grid generator allowed for specification of spatial extents and produced data sets within the limits (CRM, 2012). The parent grid utilized USACE navigation surveys wherever possible in the vicinity of the inlet. Figure 3 shows the base condition bathymetry used in the CMS-WG and Figure 4 shows the bathymetry used in the coupled CMS-Flow and NCMS-WG. In order to model the effects of the Mayport deepening project, the bathymetry was modified to represent the 50 ft MLLW (15.2 m) project depth as well as depths for advance maintenance, which resulted in depths of 54 ft MLLW (16.5 m) in some areas (see Figure 5). All model bathymetry was converted to the NAVD88 vertical datum, about 3 ft (0.9 m) above the MLLW datum around the entrance channel.

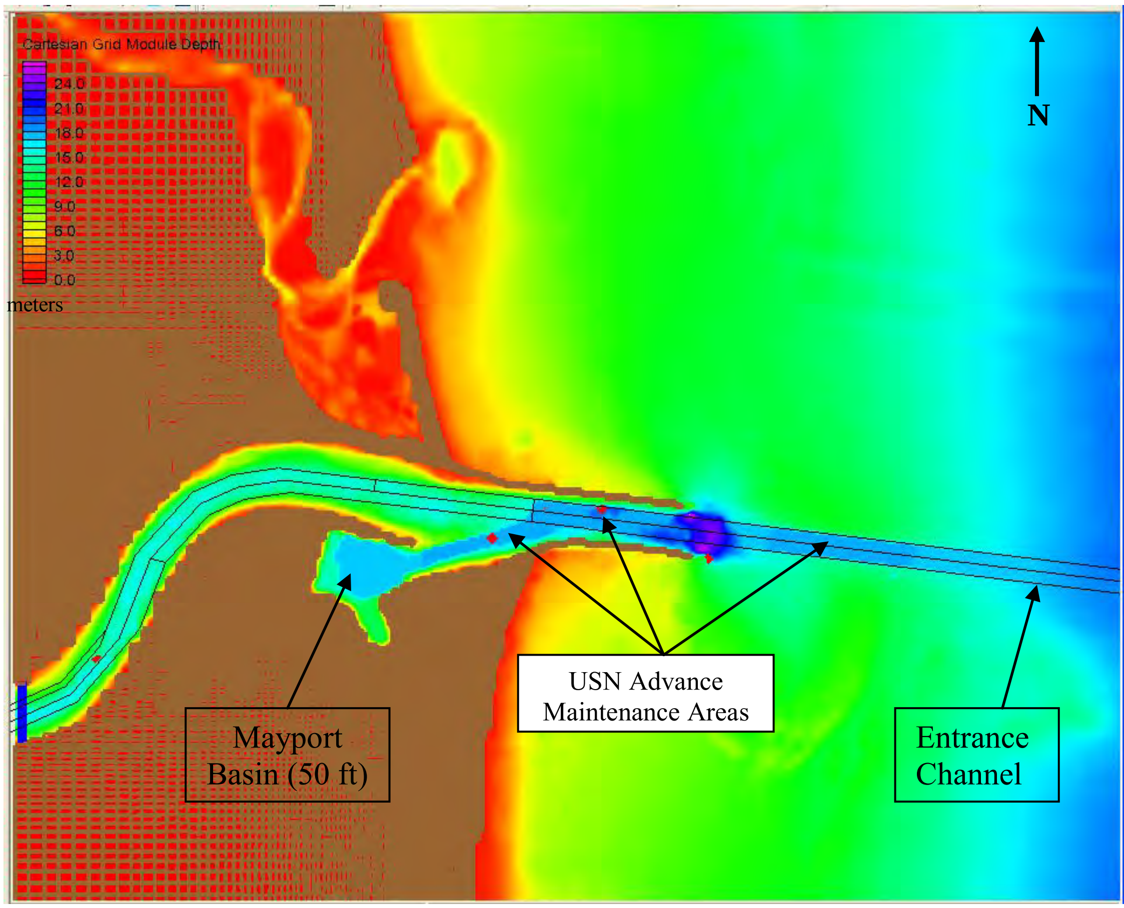

Figure 5. Jax Harbor Mayport Deepening Bathymetry Scenario.

<u>Boundary Conditions</u>

The CMS-FG has three open boundaries (offshore, St. Johns River, and the Ft. George River) that are controlled by water surface elevation forcing as well as current velocity forcing. The water levels and currents from the ADCIRC modeling (Bacopoulos and Hagen, 2010) were used as the boundary condition input for the April 1998 calibration simulation and the November 1st to 10th, 2006 and the May 10th to 26nd, 2009 Mayport deepening model scenario and for the 2009 surveyed condition (i.e. pre-Mayport deepening). The water surface elevation and velocity boundary conditions were applied over the dates 10 May 2009 to 26 May 2009 in order to capture a significant late season nor'easter. The boundary conditions for the NCMS-WG during the same period were defined using the output from the parent CMS-WG model run which utilized input from the National Data Buoy Center (NDBC) buoy #41012 and covered the period from 1 Mar 2009 to 8 Aug 2009.

Hydrodynamic Model Calibration and Verification

<u>Wave Comparison</u>

Wave parameter (height, period, and direction) results from the base channel condition model run are presented with measured data in Figure 6 at the nearshore Acoustic

Doppler Current Profiler (ADCP) measurement location off of Little Talbot Island (see Figure 2). The model data does not capture the increase in wave height (>1m) around 13 May 2009, and also lags the arrival of the late season nor'easter (Figure 6). During the storm (18-23 May 2009) the wave period is considerably elevated (5s) in the model data versus the short periods observed at the ADCP, but both wave height and direction compare well at the peak of the storm. The modeled wave direction represents the general trends of the measured data but with a tighter range of values. A direct comparison of modeled versus measured wave heights was plotted in Figure 7 and quantified by calculating the correlation coefficient (R^2) of 0.81. The center dashed line in Figure 7 represents a perfect match between the modeled and measured data (R^2=1), and the adjacent dashed lines represent the ±10% modeled significant wave height .

A comparison of energy density at the ADCP location is presented in Figure 8. The energy density represents the combined effects of wave height and period and drives sediment movement due to wave forcing. The difference in wave period is resulting in greater energy density in the modeled data since the wave heights match well during the peak of the storm (Figure 6 and Figure 8).

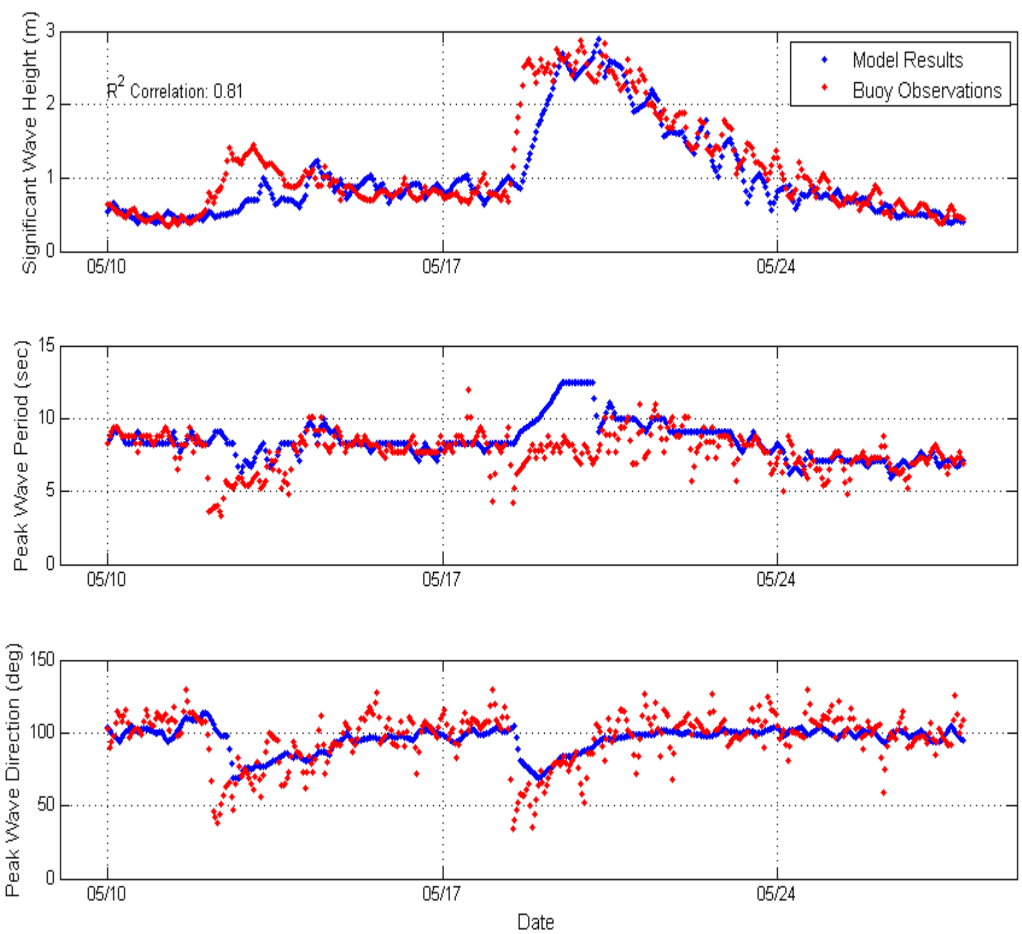

Figure 6. Modeled wave height, period, and direction comparison with nearshore ADCP measurement.

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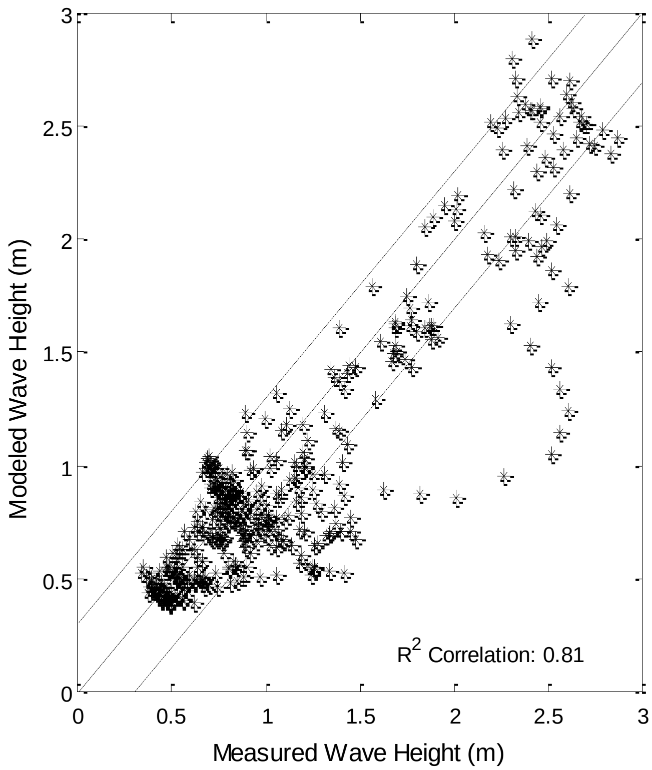

Figure 7. Modeled versus measured wave heights at nearshore ADCP gage.

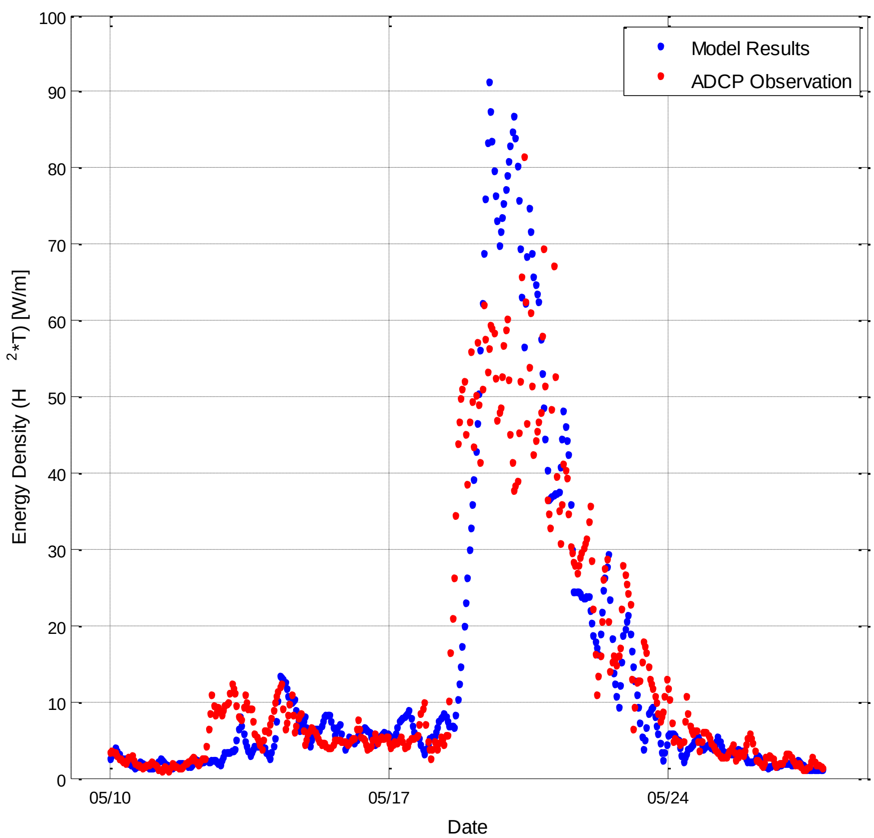

Figure 8. Modeled energy density comparison with nearshore ADCP measurement.

Water Levels

CMS-FLOW water levels were calibrated at NOS station 8720220, Mayport Ferry Dock. Figure 9 shows the comparison between CMS-FLOW and NOS 8720220 water levels for the period April 16th to 21st, 1998. Agreement between model and measured values is good, with an RMS error of 0.07 m.

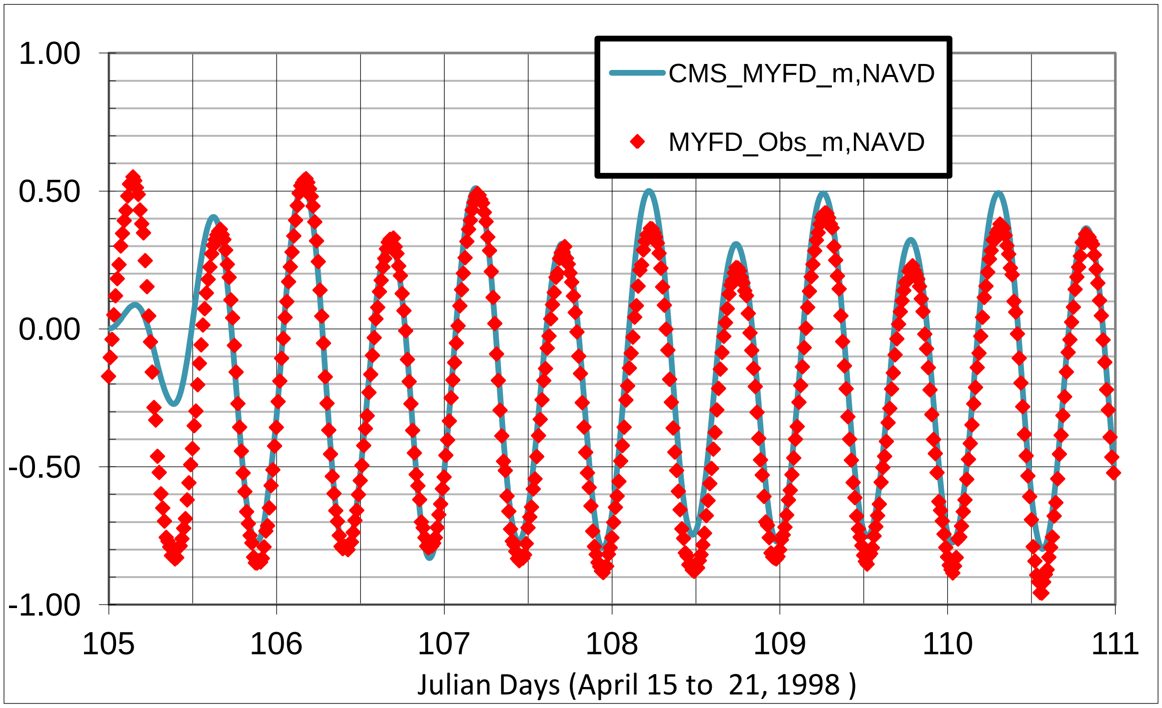

Figure 9. CMS-FLOW Mayport Ferry Dock vs NOS 8720220 Waterlevel (draft)

Currents

CMS-FLOW currents were calibrated at the NOS station SJR9801, in the inlet throat. Figure 10 shows the comparison between CMS-FLOW and NOS SJR9801 currents for the period April 16th to 21st, 2008. Agreement between model and measured values is good, with an RMS error of 0.09 m.

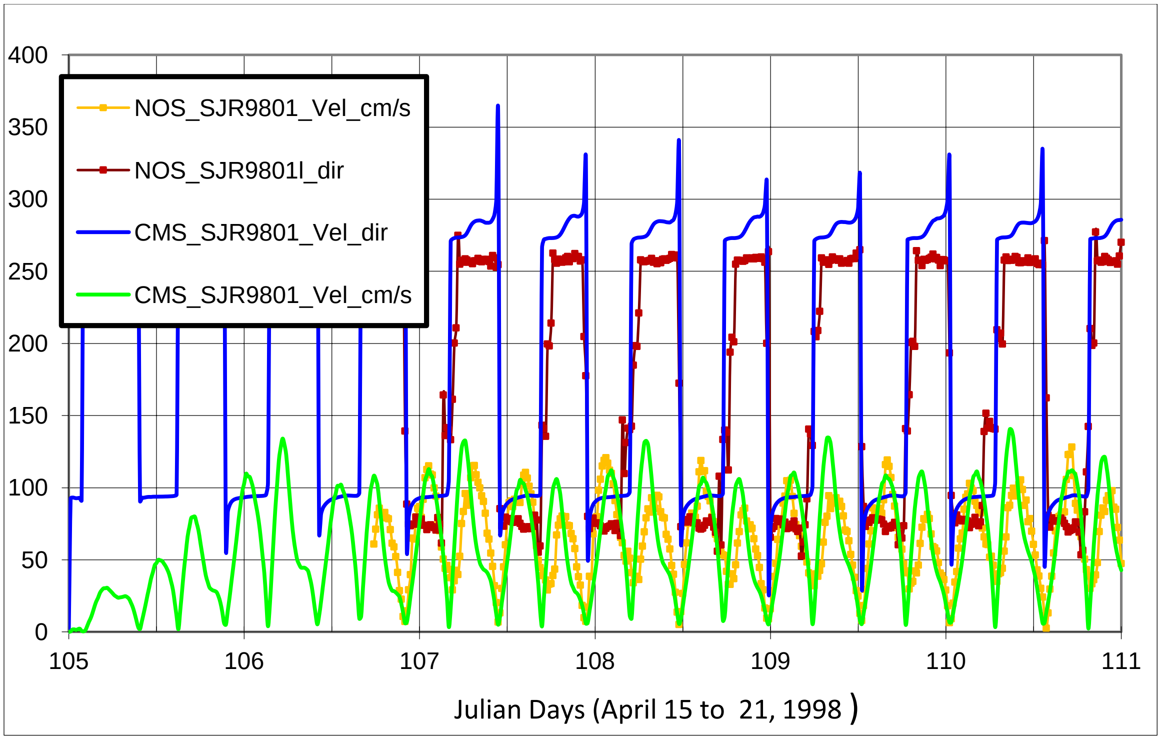

Figure 10. CMS-FLOW Current vs NOS SJR9801 Depth averaged current velocity (cm/s) and direction (Ocng or Toward - Degrees True North).

Sediment Transport Modeling for Shoaling

CMS simulations conducted for this study included CMS-FLOW simulations of bed change with the effects of waves included via input from the coupled CMS-Wave model in order to estimate the shoaling rate for the base channel condition (i.e. pre-Mayport deepening) as well as the shoaling rate as a result of the Mayport 50 ft deepening.

Sediment Transport for Pre- and Post- USN Channel Depths

May 10th to 26th, 2009

For the modeled period of 10 May 2009 to 26 May 2009, the interpolated ADCIRC boundary conditions and nested outputs from the parent CMS-Wave model run were applied over the pre-Mayport deepening and post-deepening model grids. We sought to further the understanding of the relationship between the ebb shoal and channel shoaling, specifically the boxed area shown in Figure . Maximum observed wave heights and current speeds over the analysis period equaled 3.60 m and 0.47 m/s, respectively, at the ODMDS monitoring location (see Figure 2), which is reasonable for the magnitude of the storm captured over the 18-23 May 2009 period (see Figure 11 and Figure 12). During the peak of the storm, the ADCP located off of Little Talbot Island (see Figure 2) recorded a maximum wave height of 2.87 m and a peak depth-averaged current speed of 0.91 m/s. The current directions and magnitudes were qualitatively reviewed and appeared to follow the known pattern of the ebb jet, creating an eddy that is shed near the south jetty and migrates essentially following the ebb shoal eastward then northward before dissipating with development of the flood tide.

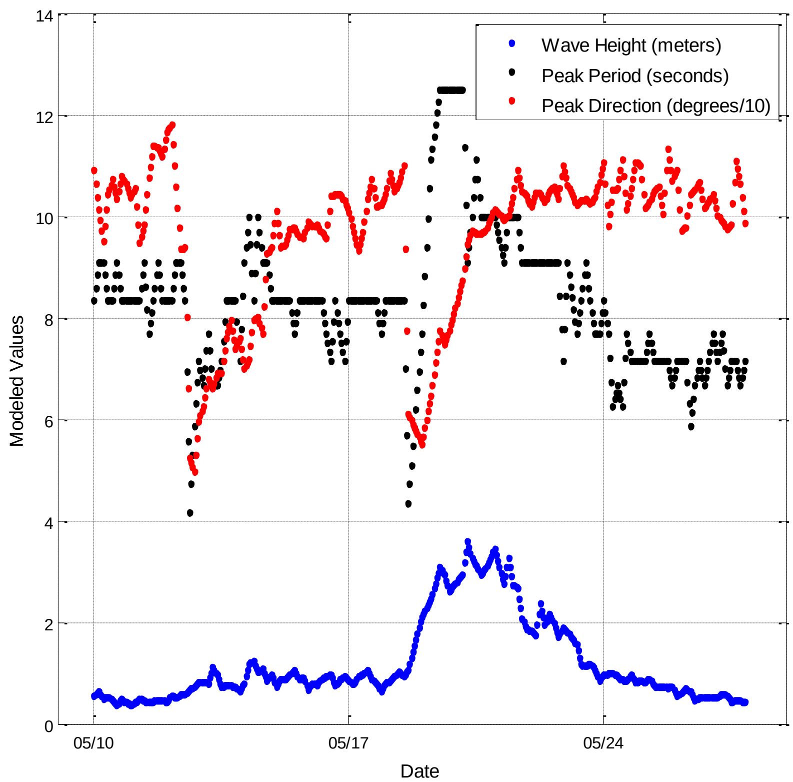

Figure 11. Modeled wave parameters at ODMDS.

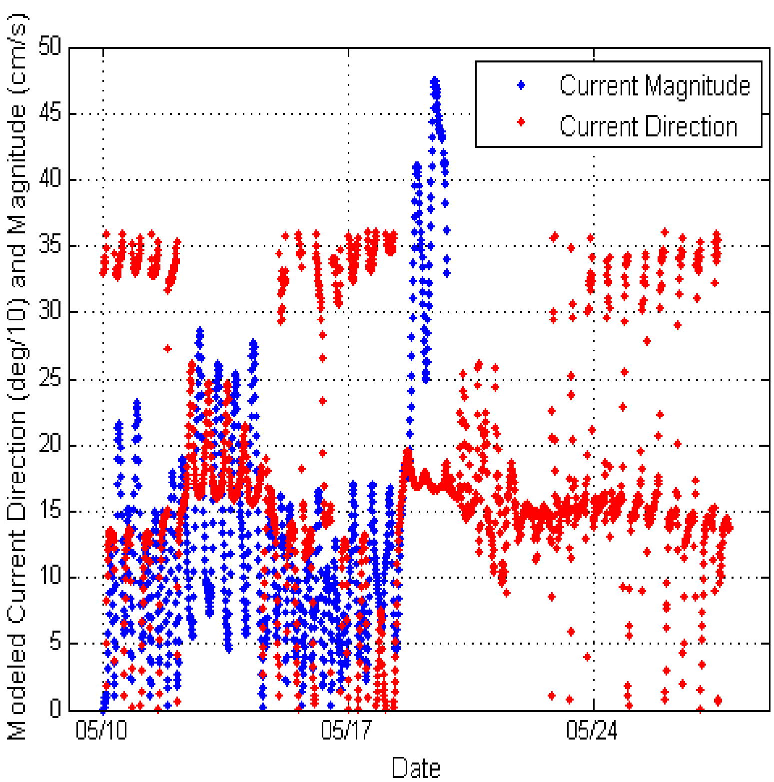

Figure 12. Modeled current magnitude and direction at ODMDS.

*currents cut off at 19:30 19 May 2009

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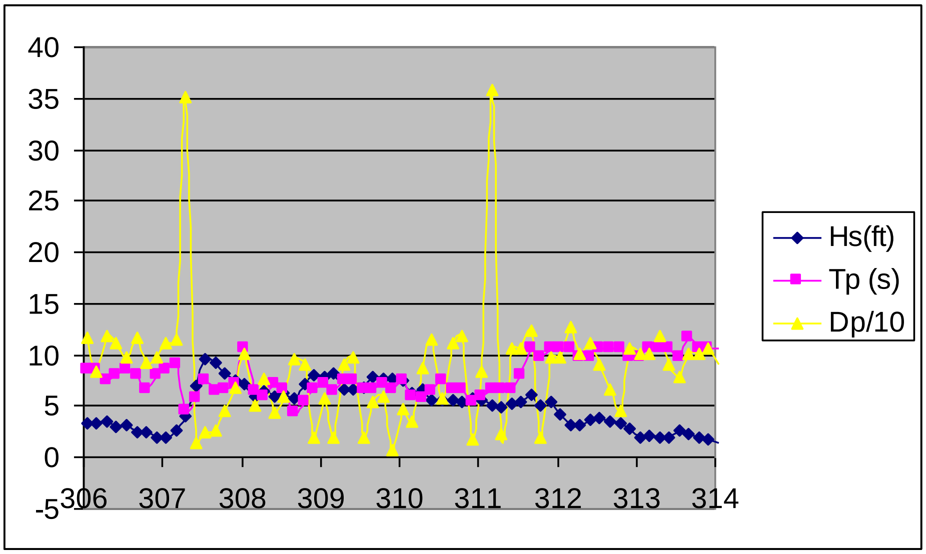
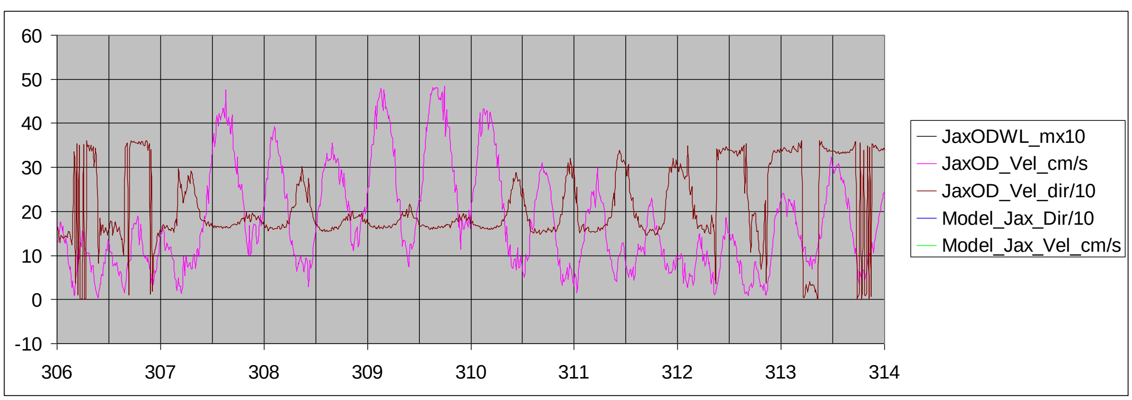
November 1st to 10th, 2006

The CMS model was also used to simulate the sediment transport of littoral sediment in the St Johns River Entrance area for with and without USN Mayport deepening for the November 1st to 10th, 2006 extratropical event. Wave and current data from the Jacksonville ODMDS ADCP for the November 2006 extratropical event are shown in Figure 14. During this period wave heights range from 2 to 3 m with a peak period of about 8 sec and a peak velocity of 47 cm/s with directions toward the south persisting for about 3.5 days. The increased currents and near unidirectional flow for the 3.5 day period represent a significant transport potential for the St Johns River Entrance Area on the inner shelf.

Figure 14. Nov2-9,2006 Jacksonville ODMDS ADCP waves and currents.(draft fig)





<u>Shoaling Volume Estimate for Pre- and Post- USN Channel Depths</u>

The results of the CMS model runs for the pre- and post-deepening of the entrance channel were used to update the shoaling rate calculated by Thomas and Dunkin (2012). Following the predictions by NAVFAC (2008), Thomas and Dunkin applied a 2% increase to the shoaling rate due to project deepening, although this value was noted as likely too low, which resulted in a value of 158,400 cy/yr over the entire entrance channel (Bar Cut 3).

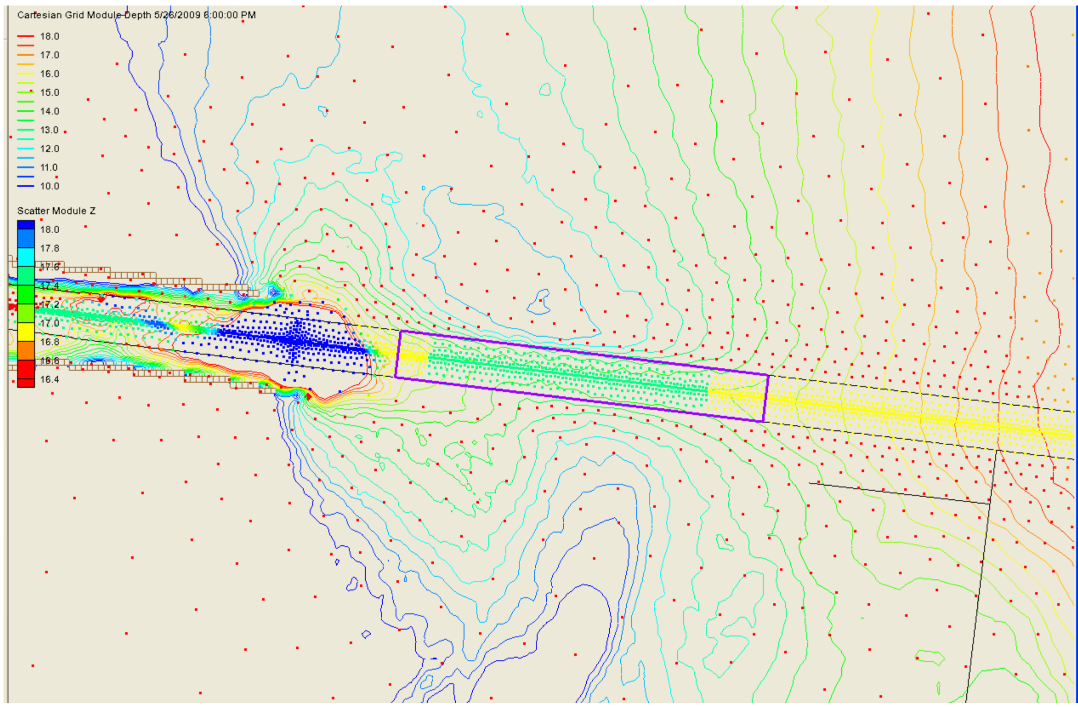


Figure 15. Entrance channel ebb shoal area of analysis.

In order to compare the pre- and post-deepening CMS model runs, a common polygon (area feature), in the vicinity of the Bar Cut 3 ebb shoal, was created to capture the storm induced changes during the modeling period, as seen in Figure 15. With the morphology model output dataset selected, grid cells were selected within the common polygon for both model runs and the SMS platform calculated the total area and volume represented by the selected cells. The without deepening condition resulted in a volume change of 59,000 cy over the polygon, and 100,300 cy for the deepened condition, as seen in Table 2. The average bed change was calculated by dividing the total volume by the total area. The difference in modeled change for the two channel conditions indicates 1.7 times more shoaling by volume between the pre- and post-Mayport deepening.

Table 2. Comparison of shoaling pre- and post-Mayport deepening, 10-26 May 2009.

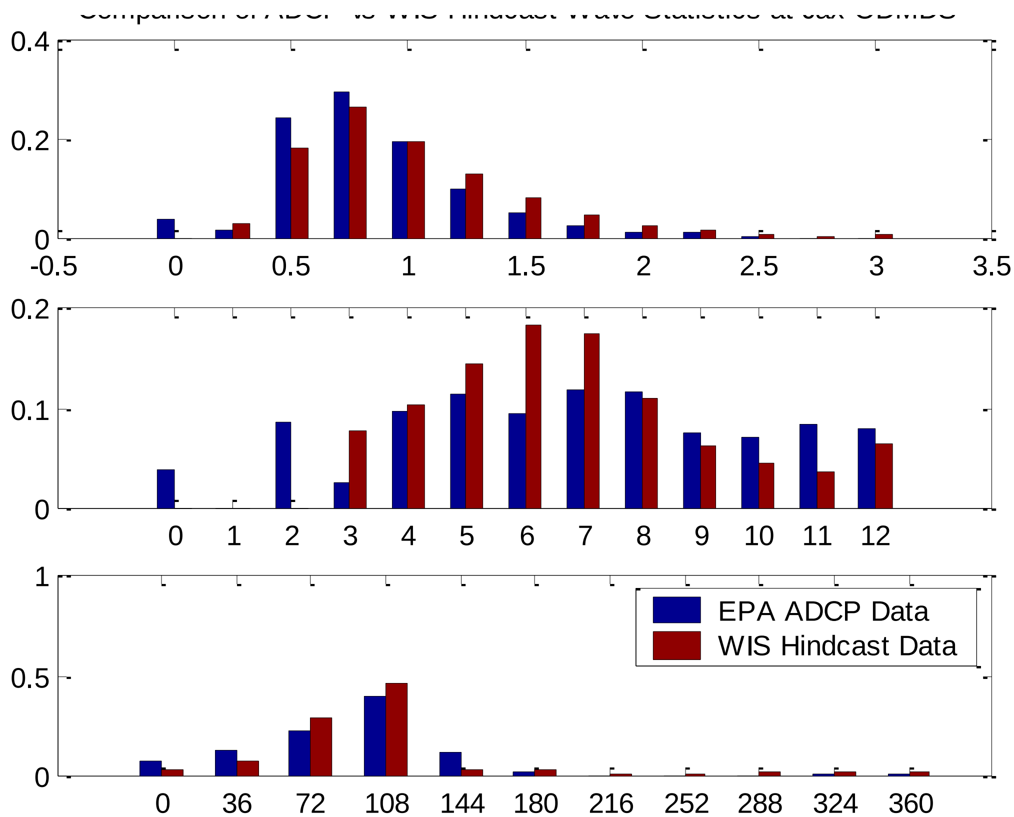
Model Run	Area (ft^2)	Volume Change (cy)	% Increase	Avg Bed Change (ft)	% Increase
2009 Condition	5,238,883	58,949		0.30	
Post Mayport Condition	5,238,883	100,283	70%	0.52	70%

Annual volume change from the survey data analysis portion of the study by Thomas and Dunkin (2012) was calculated over the same polygon in order to update the results with the increases predicted by the CMS modeling. The data were first imported into the SMS platform and interpolated onto the same CMS model grid as the pre- and post-deepening model runs. The cells within the polygon (see Figure 15) were selected and calculated to show an average annual shoaling rate of 59,300 cy/yr. Applying the model result from above- that is the effects on shoaling due to deepening the entrance channel to 50 ft MLLW results in 1.7 times more shoaling- results in an annual shoaling rate of 100,800 cy/yr over the area represented by the polygon.

The November 1st to 10th, 2006 simulated shoal volume in the Bar Cut 3 Ebb Shoal polygon (Figure 15) section of the channel, is 13 KCY for the without Mayport condition and 29 KCY for the with Mayport condition. Channel shoal volumes calculated from this event were used to estimate the annual shoaling rate for the Bar Cut 3 Ebb Shoal polygon section of the channel using the significant storm events identified in the Jacksonville ODMDS ADCP measurements are shown in Table 2. These events represent the 7 most intense storms occurring during the measurement period, which were extratropical events. Figure 16 compares wave percent occurrence from the measured wave data to hindcast wave data from Wave Information Study (WIS), Station 409, for the period from 1980 through 1999 (U.S. Army, 2008). The top panel shows significant wave height is slightly smaller during the measurement period than the 20-year average; the middle panel indicated that the measured data had slightly fewer short-period waves and proportionally greater long period swells; the bottom panel indicates that the measured data had a somewhat wider spread of wave directions. Despite these variations, the wave data for the period from August 2007 to September 2008 are quite comparable to the 20-year average for the region.

Table 2. Storm Events – Bar Cut 3 Ebb Shoal Polygon-Shoaling Volume Estimate

Storm Event	Date	Max Hs	Max Vbtm	Duration Max Vbtm above 35 cm/s	Bed Level chg (ft)	Without Mayport kcy	With Mayport kcy
		(m)	(cm/s)	(days)			
1	Sep, 10-15, 2006	2.0	35	0.5	0.09	1.95	4.35
2	Nov, 2-9, 2006	2.8	45	2.5	0.66	13	29
3	Nov, 18-25, 2006	3.0	45	1.5	0.33	6.5	14.5
4	Jan, 16-22, 2007	2.8	47	1.5	0.32	6.5	14.5
5	Mar 29-Apr 4, 2007	2.3	40	0.5	0.16	3.25	7.25
6	Apr 19-24, 2007	2.7	45	0.5	0.16	3.25	7.25
7	May 5-13, 2007	3.0	44	3.0	0.66	13	29
	Annual Volume Estimate (2006/2007) (KCY/YR)					47.45	105.85
	Annual Bed Level Change Estimate (2006/2007)				2.5 ft		



Figures 16. Comparison of measured data from Jacksonville ODMDS ADCP gage with 20-year average WIS hindcast data. Top panel is significant wave height (meters); middle panel is dominant wave period (seconds); bottom panel is wave direction (degrees CW from north).

In order to estimate the annual shoaling rate for the Bar Cut 3 Ebb Shoal polygon section of the channel for the Mayport Deepening, the shoal volume for the simulated storm event No. 2 (Table 2) was weighted proportionally to the significant wave and storm duration for each of the 7 storm events shown in Table 2. These weighted estimates of shoal volume for each event were summed to calculate an estimate of the annual shoaling in the Bar Cut 3 Ebb Shoal polygon section of the channel. The annual shoal volume for the without Mayport condition is 47 KCY and for the with Mayport condition, 105 KCY. This represents an increase in annual shoal volume of 2.2 times. Similar to the volume the bed level change from the simulated storm event No. 2 was weighted proportionally to the significant wave and storm duration for each of the 7 storm events and summed to calculate an estimate of the annual bed level change in the Bar Cut 3 Ebb Shoal section of the channel. The estimated annual bed level change for the Mayport deepening is approximately 2.5 ft. (Table 2). This shoaling volume estimate is comparable to the annual estimate based on the May 10 to 26, 2009 simulation and the Bar Cut 3 ebb shoal polygon volume from the Thomas and Dunkin (2012) historical estimate.

Summary and Conclusions

A coastal process analysis of the St Johns River entrance was conducted, including a historical shoaling estimate based on historical bathymetry surveys of the channel and adjacent areas and a coupled hydrodynamic wave and sediment transport model, the Coastal Modeling System (CMS). The analysis of channel shoaling due to the 2012 entrance channel deepening to 50 ft MLLW by the USN provides a preliminary quantification of shoaling volume due to a large late season May 2009 nor'easter and a comparable November 2006 nor'easter and also provides some insight to the coastal processes around the inlet system. The results of the analysis agree with the results extrapolated from the storm analysis of the 2006 to 2007 period using the model results from the 2 to 9 November 2006 period. The two methods of estimating annual change for the two channel conditions indicates 1.7 to 2.2 times more shoaling by volume, from 59,000 cy/yr (historic rate) to approximately 100,000 cy/yr (simulated estimate) between the pre- and post-Mayport deepening.

The development of the model will continue in order to better represent the hydrodynamics and sediment transport of the system, as well as to further develop shoaling rate and sediment pathway changes due to the channel modifications recommended by the 2013 General Reevaluation Report for Jacksonville Harbor.

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ERDC/CHL

Coastal and Hydraulics Laboratory

US Army Corps of Engineers®
Engineer Research and Development Center

Attachment I - SHIP SIMULATION NAVIGATION STUDY FOR ST. JOHNS RIVER GRR-2 IMPROVEMENT PROJECT DATA REPORT

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INTRODUCTION

St. Johns River (Figures 1, 2, and 3) is located on the northeast corner of the state and provides service to the port of Jacksonville (JAXPORT). The US Army Corps of Engineers District, Jacksonville (SAJ) is evaluating proposals to deepen the channel to up to 50 ft and possibly widen portions of the channel. There were three original proposed alternative channels. Alternative 1 (GRR-2 Alt 1) deepened to 50 ft on the existing channel footprint. Alternative 2 (GRR-2 Alt 2) deepened to 50 ft and included some widening and turning basins. Alt 2 is shown in Figure 4 and 5. Alternative 3 (GRR-2 Alt 3) deepened to 50 ft and included some widening and turning basins. Alt 3 is shown in Figure 6 and 7.

The U. S. Army Engineer Research and Development Center (ERDC) conducted a navigation study utilizing real-time ship simulation modeling to evaluate the proposed improvements to St. Johns River. Model development and online testing occurred at the ERDC Waterways Experiment Station (WES) in Vicksburg, MS during the period from January 2010 to December 2010.

RECONNAISSANCE TRIP

The Reconnaissance trip for the study was conducted February 24 and 25, 2009. The purpose of the trip was to ride ships through the project site with representatives of the St. Johns River Bar Pilots. On the 24th, Mr. Phillip Sylvester (SAJ), Dennis Webb (ERDC), and Mario Sanchez (ERDC) rode a containership inbound to the Blount Island container terminals. On the 25th, the same three Corps employees rode the same ship outbound.

DATABASE DEVELOPMENT

Currents for both the existing and proposed channels were calculated by SAJ. Currents for most of the project site were calculated using a two dimensional model. However, currents in the area extending from Mayport Cut to White Shells Cut were calculated using a three dimensional model developed for a previous Mile Point Study, (Webb, in preparation). The previous study for Mile Point was conducted in 2006. It consisted of a ship simulator based navigation study of Mile Point to evaluate a proposal from SAJ to increase the cross-sectional area for flow into and out of Pablo Creek. The purpose of the proposed widening of the mouth of Pablo Creek was to reduce ebb tidal restrictions for ship transiting St. Johns River. That study concluded that the proposal, referred to as Mile Point Alternative 1, could reduce or eliminate tidal restrictions. Mile Point Alternative 1 is not to be confused with GRR-2 Alt1. Mile Point Alternative 1 is shown in Figure 8.

The study to evaluate the GRR-2 proposals to deepen and widen St. Johns River assumes that the Mile Point Alternative 1 will be constructed. The three dimensional model used to calculate currents from Mayport Cut to White Shells Cut was operated with Mile Point

Alternative 1 in place. If the Mile Point Alternative 1 is not to be constructed, the results of the GRR-2 simulator study will be invalid. If so, the three dimensional current model will have to be run to calculate currents with the new Mile Point Alternative in place. After that, the ship simulations for that area will have to be rerun.

The visual scene was developed from the digital photographs taken during the recon trip. Figure 9 shows the visual scene as one of the St. Johns River Pilots operates the simulator.

Ships used during the simulation test program were as follows:

1. Susan Maersk, 1140- x 140- x 47.5-ft containership
2. Hanjin Miami, 980- x 141 x 47.5-ft containership
3. Generic Panamax, 965- x 106- x 44.- ft conainterhip
4. H. A. Sklenar, 797- x 106- x 47.5-ft bulk carrier

FIRST ROUND OF TESTING

Testing of the three (Alt 1, Alt 2, and Alt 3) GRR-2 channel alternatives was accomplished in July and August of 2010. All three GRR-2 alternatives were tested individually, numerous times. Captains Bill Brauer, Chris Mons, Jay Winegeart, and Joe Heath of the St. Johns Bar Pilots participated in the simulation study to evaluate the channel segments. Captains Tony Hogg and Dan Ramsey, docking pilots for St. Johns River, participated to evaluate the proposed turning basins.

The alternatives were run at a depth of 50 ft. It should be noted that simulation results for a 50 ft channel can be considered valid for channel depths less than 50 ft. Ships loaded for the 50 ft channel would tend to be heavier and more sluggish than those loaded for shallower channels. Therefore the 50 ft depth would be considered a more difficult scenario than the lesser depths.

Note, for the remainder of this report all alternatives (referred to as "Alt #") are GRR-2 alternatives, not Mile Point Alternatives. But, Mile Point Alternative 1 is assumed to be in place for all GRR-2 Alts.

Evaluation of the results from the first round of testing was accomplished through a series of meetings attended by the pilots, SAJ, and ERDC.

On September 16th, 2010 a working group was held at the St. Johns Bar Pilots office in Mayport, FL. The US Army Corps of Engineers was represented by Steve Conger, Phil Sylvester, Laurel Reichold (all of SAJ), and Dennis Webb (ERDC). St. Johns Bar Pilots were represented by Captains Chris Mons, Bill Brauer, Jay Winegeart, and Joe Heath. The objective of the working group was to evaluate the three channel improvement GRR-2 alternatives (Alt 1, Alt 2, and Alt 3) for each channel segment of the waterway. These three alternatives had been examined during a real-time ship simulation effort conducted at the ERDC Ship Simulator in Vicksburg, MS. The four pilots present at the working group had participated in the simulations.

The group examined vessel track plots of the simulation and notes taken during the simulation. Personal observations were also recalled. This took approximately four hours and resulted in a consensus opinion on a new alternative channel. A detailed memorandum from SAJ of the analysis of Alt1, Alt 2, and Alt 3 is included in Appendix A. This new channel, Alt 4, is a combination of the most appropriate of GRR-2 alternatives Alt 1, Alt 2, and Alt 3 for each channel segment. In addition, two minor modifications not included in the three previous alternatives were added to Alt 4. The Alt 4 channel is shown in Figures 10 and 11.

Alt 4 is described in Table 1. Two-way traffic for the design ships is provided for in Training Wall Area, Brills Cut, and Drummond Creek. Table 2 describes the widening, referenced to the St. Johns River Cut number used by SAJ.

An additional Alternative, Alt 5 was also developed. The only change from Alt 4 was additional widening on the northwest side of St. Johns Bluff reach. Alt 5 will only be simulated for St. Johns Bluff reach and its approaches since the remainder of Alt 5 is identical to Alt 4. The Alt 5 Channel is shown in Figures 12 and 13.

Table 1. Alt 4 channel	
Channel Segment	Alt selected for Alt 4
Mile Point	Alt 2
Training wall reach area	Alt 3
Additional short cut turn widening	Not part of early Alts
Additional widening on nw side of st. johns	Not part of early Alts
North St Johns bluff	Alt 2 + additional
Southern increment west of St Johns bluff	Alt 2 + additional
Brills cut	Alt 3
Broward point	Alt 2 + additional on south
Drummond creek	Alt 2
Trout river cut	Alt 3
Chaseville turn	Alt 2

Table 2. Widening Descriptions		
Channel Segment	**Cut**	**Widening Measure**
Sherman Cut Range	8	200 ft on the Red Side
	9	200 ft on the Red Side
	10	200 ft on the Red Side
	11	200 ft on the Red Side
	12	200 ft on the Red Side
	13	200 ft on the Red Side tapering into Cut 14 at Atlantic Drydock
	13	Tapering out to 100 ft on the Green Side at Cut 14
Training Wall Reach	14/15	100 ft on the Green Side
Training Wall Reach	14/15	100 ft on the Green Side
Training Wall Reach	16	100 ft on the Green Side expanding to 250 ft in Cut 17
Short Cut Turn	17	250 ft on the Green Side
Short Cut Turn	18	100 ft on the Green Side
Short Cut Turn	19	100 ft on the Green Side
St Johns Bluff Reach/White Shells Cut	40	400 ft on the Red Side tapering to 200 ft at Cut 41
	40	300 ft on the Green Side
	41	200 ft on the Red Side
	41	Varies on the Green Side to match old 38 ft project limits
Dames Point Fulton Cutoff Range	42	Varies on the Green Side to match old 38 ft project limits
Brills Cut	45	100 ft on the Green Side
Broward Point Turn	49	200 ft on the Green Side
Drummond Creek Range	50	200 ft on the Green Side
Trout River Cut	51	100 ft on the Red Side tapers into Cut 52 at NuStar
Chaseville Turn	54	200 ft expansion of the Chaseville Widener at the apex
Terminal Channel (T.C.)	N/A	100 ft on the Green Side
Blount Island Turning Basin	42	Approx 2672 ft long by 1500 ft wide
Brills Cut Turning Basin	45	Approx 2500 ft long by 1500 ft wide
Talleyrand Turning Basin	T.C.	Approx 3025 ft long by 1500 ft wide

RESULTS

One week of real-time pilot testing was undertaken for the Alt 4 and Alt 5 channels. Captains Chris Mons and Bill Brauer St. Johns Bar Pilots Association operated the simulator November 9 - 12, 2010.   Captains Steve Harvey, Dan Ramsey, and Tony Hogg, docking pilots for the Port of Jacksonville, participated in the turning basin simulations December 6 – 10. The plates referenced in the results are included in Appendix B.

<u>Mayport Cut to Dames Pt Fulton Cutoff.</u>

Meet in Training Wall Reach

The track plot of an outbound Hanjin Miami meeting an inbound Hanjin Miami during ebb tide in Alt 4 is shown in Plate 1. The two ships meet in Training Wall Reach. The run was successful.

The inbound pilot had the following comments:

1. *Obviously strong adverse current in mile point, but the widening between buoy "22" and training wall reach allowed for me to set up for the meeting in training wall.*
2. *At buoy "24" Pablo Creek mitigation fix made current at ICW much more manageable.*

3. *While meeting outbound post panamax vessel Hanjin Miami, I was at extreme edge of channel (feeling bank suction pretty hard). It was just enough to give outbound the full half of the channel needed considering angle of attack with regard to baseline for training wall taking into account current and slide while entering training wall from short cut.*

4. *New configuration and position of "25" softened entrance into short cut turn created a better configuration for larger vessels.*

The outbound pilot had the following comments:

1. *Felt no significant chng in current due to new Mill Cove turning basin.*

2. *Half ahead and hard over 100% thru short cut ('27' past '25') to make turn. Note half ahead is a 12.8 knot bell. Would not want to give up any of the widening here.*

3. *Turn @ '25' – slid to red side: with hdg 137 degrees, stern was on range and bow was outside over widened green channel edge.*

4. *Met @ Atl Marine – vessel was consuming more than ½ channel approaching meet, lost concentration for approx 5 seconds as ships' sterns passed. Interaction between sterns caused shear towards '24'. Regained control and barely stayed in channel, then turned mile point well.*

5. *Above momentary HO/HU (hard over/hooked up or full ahead) correction necessary to stay in channel resulted in SOG of 10.9 kts, entering mile point w/ 47.5 foot draft in 50' channel. Squat of similar vsl "MOL Product" is 1.4 meters at 10 kt. Correction would have resulted in theoretical grounding.*

6. *Hard over and half ahead maintained to make necessary rotation thru mile point. More slowing before straight away was impossible.*

7. *Again, new configuration is minimum necessary to functionally meet with Panamax size vessels.*

The track plot of an outbound Hanjin Miami meeting an inbound Hanjin Miami during flood tide in Alt 4 is shown in Plate 2. The two ships meet in Training Wall Reach. The run was successful.

The inbound pilot had the following comments:

1. *Widening between "22" and "24" critical to set up for meeting in training wall.*

2. *While meeting two Hanjin Miami vessels in training wall, very strong interaction between other vessel and bank. There is not very much room while meeting two vessels of a 141 ft beam when vessels are accounting for slide from turn, and current effects.*

The outbound pilot had the following comments:

1. *Met at the new "24" position which is right at intersection of turn. Also it sits in front of the Atlantic Dry Dock which is in the way of putting vessels on and off the dry dock. Buoy will have to be moved for this reason. The meeting seemed a little tight with the inbound experiencing the slide at "24" while turning into training wall reach. Moving the buoy may make it look less tight, but the meeting went well.*

The track plot of an outbound Hanjin Miami meeting an inbound Susan Maersk during flood tide in Alt 4 is shown in Plate 3. The two ships meet in Training Wall Reach. The Hanjin Miami left the south-west side of Training Wall Reach by about 50 ft. Inbound pilot commented that he left channel slightly on red (north-east) side during meet. Track plot indicates that the Susan Maersk left channel by less than 5 ft.

The inbound pilot had the following comments:

1. *Immediately dropped to dead slow (Mons went 60% - no local control)*

2. *Me DS @ ‘18’ = Mons full ahead @ ‘35’*

3. *Susan handled well through Mile Point on dead slow ahead.*

4. *Did my damnedest to stay in but left channel slightly on red side during meet.*

5. *Mons left green side just past ‘27’ but was in good shape for meet.*

6. *Again, BIG interaction and dive at stern to stern part of meeting.*

The outbound pilot had no comments.

The track plot of an outbound Hanjin Miami meeting an inbound Hanjin Miami during ebb tide in Alt 4 is shown in Plate 4. The two ships meet in Training Wall Reach. The Hanjin Miami left the north-east side of Training Wall Reach by about 70 ft.   However, this was cause by simulator operator error (not pilot error).

The inbound pilot had the following comments:

1. *After 1 wrong rudder response (helmsman error) did best to get back into shape before meeting and still ran over buoy ‘24’ and left channel @ ‘24’ even using hard over rudder and full ahead.*

2. *Got more or less back into shape before meeting but still scraped paint with outbound Susan.*

3. *It should be stressed that many of these successful runs exhibit the minimum acceptable channel width for a successful (non-catastrophic) meet under optimum conditions.*

The outbound pilot had the following comments:

1. *Run 14 Outbound Ebb on Susan Maersk, met in Training Wall Reach -Very strong interaction between vessels in training well. Strong turning couple as passing between the bank on my starboard quarter and the port bow feeling the other vessel’s stern.*

Meet in St. Johns Bluff

The track plot of an outbound Hanjin Miami meeting an inbound Hanjin Miami during ebb tide in Alt 4 is shown in Plate 5. The two ships meet in St. Johns Bluff. The run was successful.

The inbound pilot had the following comments:

1. *Met middle of Bluff – sufficient room for meeting – could possible give back* ***some*** *per ALT 5 by making northern "east-west" channel line into 2 legs angled down to middle of cut (old '34' location).*

2. *Had more trouble staying in shape entering and transiting E end of cutoff.*

3. *Again, no appreciable difference in current passing Mill Cove turning basin*

The outbound pilot had the following comments:

1. *No appreciable change in current effects at mill cove from new Blount island turning basin -Alternative 4 (maximum width at 34) position of "34" maximizes passable length of channel in area. The maximum north edge of channel may not be required fully required to achieve goals for the area. Meeting outbound went well.*

The track plot of an outbound Hanjin Miami meeting an inbound Hanjin Miami during flood tide in Alt 4 is shown in Plate 6. However, the data for the inbound ship was lost due to a simulator malfunction. The two ships meet in St. Johns Bluff. The run was successful.

The inbound pilot had the following comments:

1. *Alternative 4 bluff configuration ideal for meeting.*

The outbound pilot had the following comments:

1. *This is comfortable but, again – seems like we could give back a little here.*

The track plot of an outbound Hanjin Miami meeting an inbound Hanjin Miami during flood tide Alt 5 is shown in Plate 7. However, the data for the inbound ship was lost due to a simulator malfunction. The two ships meet in St. Johns Bluff. The run was successful.

The inbound pilot had the following comments:

1. *Did not like the Alternative 5 bluff configuration. It puts buoy 34 in a bad spot, and the widening to the north is not useable. It forced both vessels to be in a dynamic state while passing. I swung my stern into the water he was trying to get to. Moving the edge north in alternative 5 didn't seem to capture the benefits of widening there.*

The outbound pilot had the following comments:

1. *Just learned that, contrary to paper chart and ECDIS display, currents related to new Mill Cove Turning Basin are present in Alt 5 and NOT present in Alt 4. Note: Felt no change in current effect in either Alternative scenario passing Mill Cove turning basin @ 6 to 7 knots SOG.*

2. *Note that East end of Cutoff is 475' wide. Training Wall is 475' wide and Brills Cut is 425' wide. All tough places to meet Panamax vessels.*

3. *Outbound in east end of Cutoff, centerline conning position exactly on visual range, ECDIS shows port wing on range = 70' to 75' discrepancy : Note that last run I was told to trust ECDIS and not visual '58'. Now visual is a range, not likely a data input error.*

4. *With Mons inbound in center of inbound, and outbound (Brauer) straddling old channel edge, meet was pretty darn close.*

5. *Mons & Brauer both advocate modified Alt 4/Alt 5 arrangement keeping '34' as far down river as in alt 4, and increasing area to meet while turning.*

The track plot of an outbound Hanjin Miami meeting an inbound Hanjin Miami during flood tide during Alt 5 is shown in Plate 8. The two ships meet in St. Johns Bluff. The run was successful.

The inbound pilot had the following comments:

1. *Very difficult with this configuration. *** I think we should come up for an alternative in between alternatives 4 and 5 for this area.*

The outbound pilot had the following comments:

1. *Entered Bluff w CN112, turned to port at what I considered the last safe moment, she rotated better than expected so I steadied her up on CN090, then was convinced that inbound would have insufficient channel, so let her come back right just a few degrees, then went hard left again. This time response was sluggish and I was convinced she would ground on green side. Flood and bank effect helped and I was able to meet (very courteously) and stay in channel but meet was VERY uncomfortable! Again, Alt 5 "Bluff" configuration is much less safe than Alt 4.*

2. *The width is less important here than the down-river location of '34'.*

The track plot of an outbound Susan Maersk meeting an inbound Hanjin Miami during ebb tide during Alt 5 is shown in Plate 9. The two ships meet in St. Johns Bluff. The run was successful.

The inbound pilot had no comments:

The outbound pilot had the following comments:

1. *Meet @ '34'*

2. *Again, dove toward Mill Cove turning basin, but now with EBB!*

3. *Meet was good, immediately downriver of '34'*

4. *Susan is exceptional handling vessel. Handles much better than Panamax or Hanjin Miami.*

The track plot of an outbound Hanjin Miami meeting an inbound Susan Maersk during flood tide in Alt 4 is shown in Plate 10. The two ships meet in St. Johns Bluff. The run was successful.

The pilots did not have any comments.

<u>Drummond Creek Range to Dames Pt Fulton Cutoff.</u>

Meet in Brills Cut

The track plot of an outbound Panamax meeting an inbound Hanjin Miami during ebb tide in Alt 4 is shown in Plate 11. The two ships meet in Brills Cut. The run resulted in a collision.

The inbound pilot had the following comments:

1. *Started @ berth 31 @ 8kts, dropped to dead slow ahead and had to go back to full ahead to make turn under bridge.*

2. *Then overcorrected and was about to leave red side off of TRAPAC which, in the real world is no problem as TRAPAC berths are 40', then it occurred to me that for purpose of simulations/track plot, perhaps I was expected to remain in Fed channel. Went again to full ahead and hard port.*

3. *This imparted too much speed 7.7kts approaching berth and it was apparent I'd meet the outbound off of, or upriver of, my berth.*

4. *In shape, but needing to both slow for my berth and come bow to starboard, I tried backing the engine expecting bow to starboard rotation. Opposite occurred (bow to port) and I crossed centerline and collided with outbound.*

5. *Also note that area narrows to a very restrictive bottleneck in area of '51' and down river of '51' for a short distance. Would this be affordable to*

correct/improve? Doing so would make meet possible anywhere between Broward Point and Dames Point.

The outbound pilot had the following comments:

1. *I was turning and experiencing the slide of turning into brills cut with following current and met at buoy 53. Vessels sucked together and collided alongside.*

The track plot of the rerun of an outbound Panamax meeting an inbound Hanjin Miami during ebb tide in Alt 4 is shown in Plate 12. The two ships meet in Brills Cut. The outbound ship left the channel by about 35 ft while meeting the inbound ship.

The inbound pilot had the following comments:

1. *Between above run and "Do-Over" consulted with ACOE and confirmed I can use (assume 50') the water outside the Fed cahannel off TRAPAC and aggregate dock.*

2. *Matrix run #8 (Again) Inbound – same parameters*

3. *Started 3 ship lengths further down-river and went immediately to stop engine killing speed to avoid full ahead turn at bridge.*

4. *Used more speed than realistic (given proximity of berth) in order to meet at '51'*

5. *TOO NARROW TO MEET THERE!*

6. *I was hard left and full ahead and was able to keep more or less steady and as far to red side as possible, outbound sheared radically from interaction.*

The outbound pilot had the following comments:

1. *Met at buoy 51. There was strong interaction while passing. I barely recovered from the shear to port across the channel after we passed. This is an area where a small change to the channel could capture the benefits. ***There is a need to create some sort of different configuration at buoy 51 to alleviate the choke point that it has.*

The track plot of an outbound Panamax meeting an inbound Hanjin Miami during flood tide in Alt 4 is shown in Plate 13. The two ships meet in Brills Cut. The outbound ship was nearly 100 ft outside the west side of the channel while meeting the inbound ship.

The inbound pilot had the following comments:

1. *Started @ high wires w/ 5 kts & began slowing immediately/ stop engine and dead slow ahead as necessary for steering (which was most of the time DS)*

2. *Mons (outbound) had local control failures and had to give commands via VHF*

3. *Meet was optimum and still very close. Can we widen this short length of bottleneck?*

The outbound pilot had the following comments:

1. *A bottle neck definitely exists at 51. We met there again, and it is much more difficult than it needs to be. Slight geometrical changes could possibly alleviate this congestion without adding much if any digging to the project.*

<u>Talleyrand to Dames Point Turn.</u>

Meet in Drummond Creek

The track plot of an outbound Panamax meeting an inbound Panamax during ebb tide in Alt 4 is shown in Plate 14. The two ships meet in Drummond Creek. The run was sucessful.

The inbound pilot did not comment:

The outbound pilot had the following comments:

1. *Wider Drummond creek range necessary for meeting deep draft 106 ft beam vessels. This will also be critical for the Keystone coal terminal coming on line because the deep inbounds will be unable to adjust speed very much and delay any other vessel movements at that time. Effectively this creates a one way traffic scenario.*

The track plot of an outbound Panamax meeting an inbound Panamax during flood tide in Alt 4 is shown in Plate 15. The two ships meet in Drummond Creek. The outbound pilot did go out of the channel while meeting the inbound ship, but the pilots seemed to think the channel was wide enough

The inbound pilot had the following comments:

1. *Good meet in Drummond Creek range – My port wing on range and Mons (outbound) on channel edge.*
2. *Sufficient distance between vessels but BIG stern to stern interaction rotating me right 3 degrees against hard port rudder.*
3. *Note: Any evaluation of necessary channel width must take into consideration the magnified hydrodynamic interaction between 2 ships that are each large, powerful, and deep draft.*

The outbound pilot did not comment:

Turning Basin Tests

Four different turning basins were tested. They were located at Blount Island, Brills Cut, Broward Point Turn, and Talleyrand. All turning basins were combined with the Alt 5 channel. Talleyrand had three turning basin layouts, Alt 5, Alt 6, and Alt 7. These alternatives are shown in Figure 14. The docking pilots stated that the currents in the simulator were not as strong as those they encounter in real life. Therefore current multipliers ranging from 1.7 to 2.5 were used for most simulations.

Turning in Blount Island Basin

Track plots of turning maneuvers in the Blount Island Basin are shown in Plates 16, 17, 18, and 19. The docking pilots had the following comments.

1. *The simulations showed that the proposed basin was adequate for these larger vessels on both the flood and the ebb.*
2. *This model tested well and provided adequate turning and maneuvering space for the post panamax model Susan Maersk at ebb and flood conditions. It must be noted however that the model does not accurately exhibit true to life current set at base velocities that are installed for the exercise, nor does the model handle correctly when higher velocities are applied for a maximum current simulation. The model did, however, provide an accurate depiction of turning radius of the vessel even when considering a vessel moored at the adjacent bulkhead. This basin is anexcellent design and will provide favorable service with a good margin of safety built in.*
3. *Design worked well on both flood and ebb current. There was adequate room to safely maneuver the 1140' Susan Maersk model with vessels in the berth adjacent to the turning basin.*

Turning in Brills Cut Basin

Track plots of turning maneuvers in the Brills Cut Basin are shown in Plates 20, 21, 22, and 23. The docking pilots had the following comments.

1. *The simulations also seem to be adequate if the Port Authority can determine the location and proposed set back of the face of the new terminal. Adjustments will have to be made once the exact location of the terminal dock and turning basin are determined to allow for vessels in the berth.*
2. *Brills Cut Turning Basin has good potential; however without knowing the location of the Hanjin Terminal, it is premature to make any recommendations. The design as presented for the exercise is approximately 1250' wide. If the basin is located adjacent to the terminal then I recommend 1700' width to allow for turning when vessels are in berth. If the basin is not adjacent to the terminal then I recommend 1500' width.*
3. *This basin has the potential to be just as functional as Blount Island's proposed basin, however, the basin needs to be designed with a width of 1750 ft and a length of 2500 ft. These dimensions need to be established if the basin were to lie directly off of the bulkhead. If the basin is to be independent of any berthing areas, the width would need to be 1500 ft minimum. The widths mentioned above are arrived at considering an industry standard of a 1.4 turning radius for the vessel and then adding 150ft for the beam of a moored vessel at the bulkhead. Example: Susan Maersk LOA of 1,140ft multiplied by 1.4 =1,596ft + 150ft beam of moored vessel= 1,746ft total. This basin tested well and the design is definitely agreeable in all ways once above dimensions are applied. To arrive at a conclusive finding, two issues need to be addressed. 1} Basin's definite location 2} Will a berth lie within its boundaries.*

Turning in Broward Point Basin

Track plots of turning maneuvers in the Broward Point Basin are shown in Plates 24, 25, 26, and 27. The docking pilots had the following comments.

1. *Broward Point Turning Basin is problematic. With the confluence of Dunn's Creek and Broward River in the turn, conditions are constantly changing thus making maneuvers here highly unpredictable. The simulation failed to provide any confidence in safely utilizing this area for a turning basin. I consider this to be a poor site for further development.*

2. *Efforts on further examining this basin for development are counterproductive when considering the other alternative options that are available. The proposed location of this basin lies in an area that has continually changing current vectors throughout the entire tidal cycle. This area experiences tidal forces from the main river channel as well as Dunn Creek and the Broward*

river as well as being located on a 90 degree turn in the river next to a petroleum berth. Above mentioned factors coupled with many unsuccessful attempts in simulation, that would only multiply in real life, compel me to strongly dissuade involved parties on further research.

3. *From my practical experience of putting large vessels in Austin Terminal and Hess and from the difficulty and problems we encountered during the simulations this is not a prudent location to turn these large vessels. Due to the convergence of the currents in the bend of the turn, the St. Johns River and Dunns Creek and Broward River, this would lead to many restrictions for the vessels using this as a turning basin. This has never been a good place under ideal circumstances much less turning these larger vessels on any stage of the tide and current. This would be the least favorable place to turn a ship.*

Turning in Talleyrand Basin

Track plots of turning maneuvers in the Talleyrand Basin are shown in Plates 28 thru 33. The docking pilots had the following comments.

1. *Talleyrand Turning Basin alternative 6 is too small to allow safe maneuvering. Alternative 5 and 7 are workable alternatives however I would stress turning large vessels on the inbound transit to lessen sailing restrictions. There is also potential for congestion here as the area is within the only practical ship anchorage on the river. Vessels utilizing the anchorage could impact the ability for large vessels to maneuver. In summary, the exercises provided good information. I feel 2500' is an adequate length to turn under normal conditions. With 1140' vessels we need a minimum of 1700' width to safely turn with vessels in a berth adjacent to the turning basin. We need to determine the actual location of the Hanjin Terminal in order to make recommendations regarding the Brills Cut Turning Basin. In all instances, it is important to note sufficient aids to navigation are required to define the turning basins.*

2. *Simulations were performed on three different models for this basin that included alternates 5, 6 and 7. Alternate 6 turned out to be too constraining, especially when considering the real current set forces we know to exist in this area. This led to simulations of Alternate 5 which tested very well, however was likely more room than actually needed. We were then asked to modify and roughly construct an alternate 7 that was a combination of the two previous designs with lesser area. Alternate 7 proved to be a happy medium, so to speak, between the others and tested well during all base model applications. Please bear in mind that this is a multi purpose area for anchoring and bunkering ops and it's boundaries also lie adjacent to a berthing area at the Chevron Facility. The 1750 ft width explained in above paragraph would also be applicable in this design. I would recommend Alternate 7 to address the needs of the port in this area of the river*

3. *After studying the three options at Talleyrand, Alternate 5 was the best option to suit all types of vessels that were simulated. We realize that this was the largest of the three with Alternate 6 being the smallest. Alternate 7 would be satisfactory. Alt 6 with its limited area would be very restrictive at all stages of the tide and current.*

Conclusions

The following recommended widening measures result in successful two-way meeting of the vessels simulated:

1. Training Wall Reach (Plates 1 & 2 - 100-foot widening measure on green side)

2. St. Johns Bluff Reach (Plate 5 - 300-foot widening measure on green side)

3. Drummond Creek Range (Plate 15 - 200-foot widening measure on green side)

The Brills Cut widening measure (100-foot widening on the green side) Plates 11, 12, and 13 did not result in successful two-way meeting of the ships simulated.

Recommendations

The following are recommendations based upon the results of the simulator study. With the exceptions of St. Johns Bluff Reach and Short Cut Turn Alt 4 is recommended. Note: Alt 4 and Alt 5 are identical everywhere but St. Johns Bluff Reach. In St. Johns Bluff Reach Alt 5 was too restrictive on the north east end and Alt 4 was wider than necessary on the north west end. The widening shown in Figure 15 is recommended.

The following recommendations are made for the turning basins.

1. At Blount Island, as tested, 2500 ft length and 1700 ft total, including berth,.
2. At Brills Cut the 2500 ft by 1700 ft (including berthing area) is adequate. The final location will depend upon the terminal to be constructed.
3. At Broward Point the location is inappropriate for a turning basin.
4. At Talleyrand Alts 5 and 7 were adequate. Since Alt 7 is smaller, it should be selected.

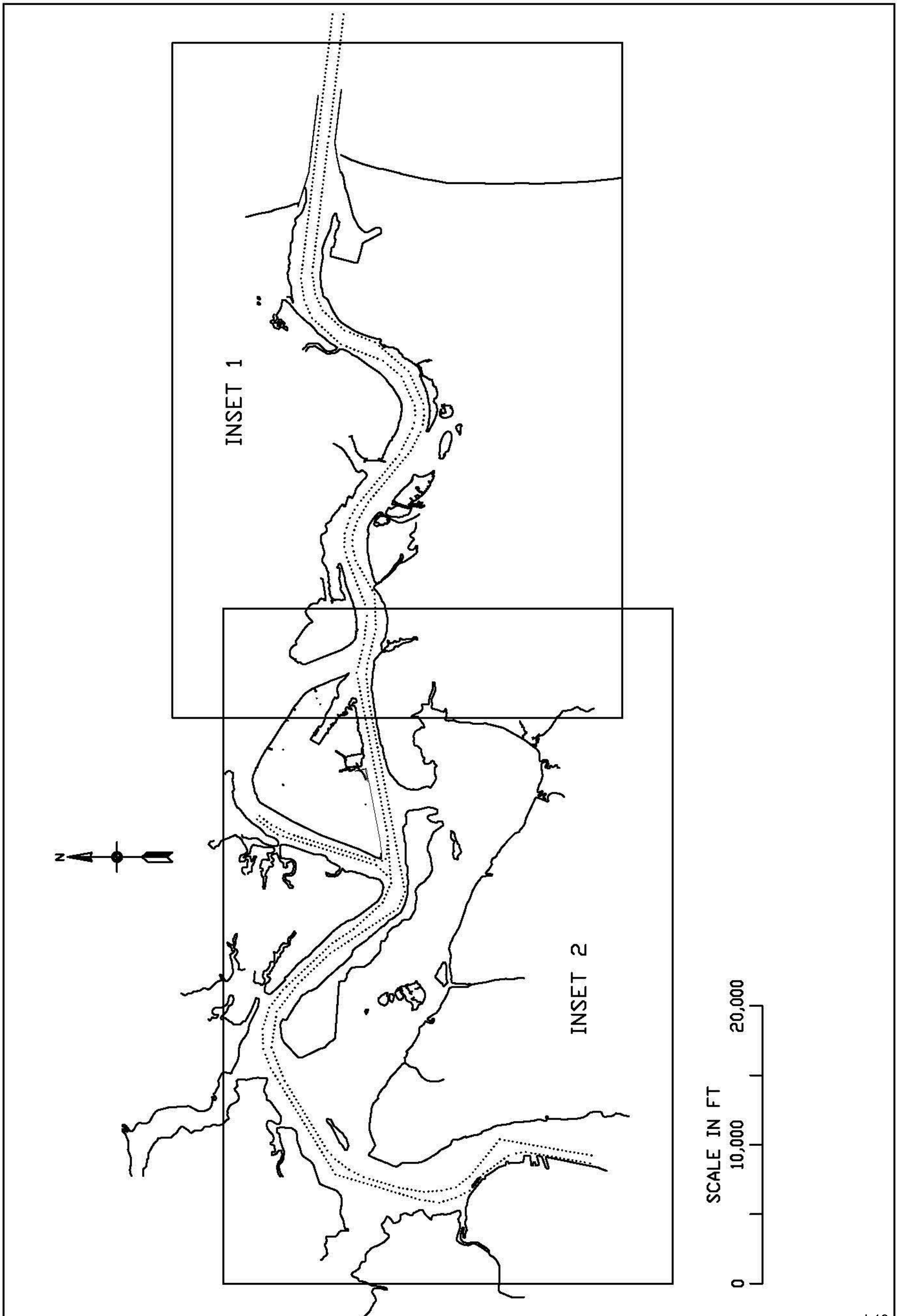


Figure 1. Saint Johns River

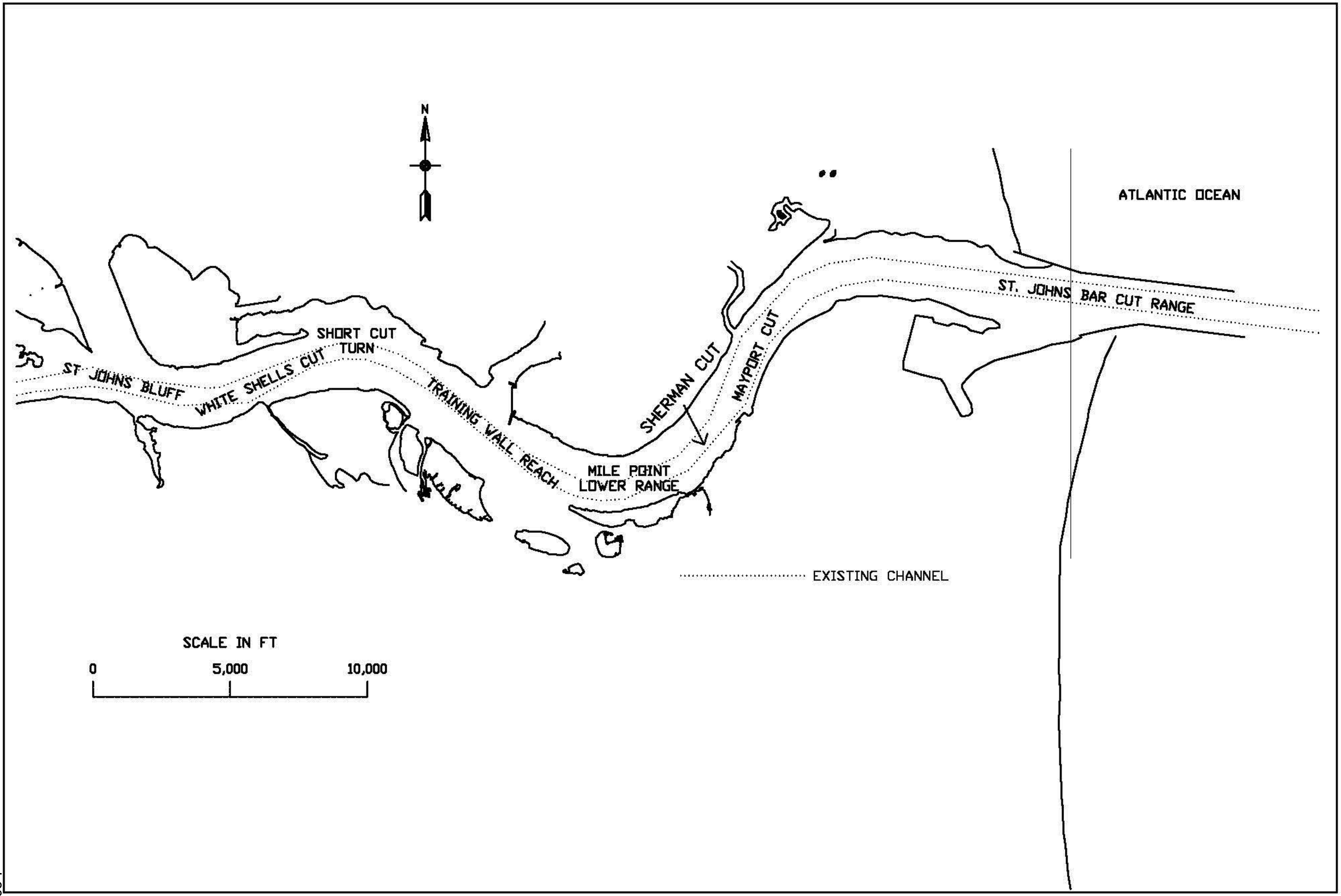


Figure 2 Saint Johns River - Inset 1

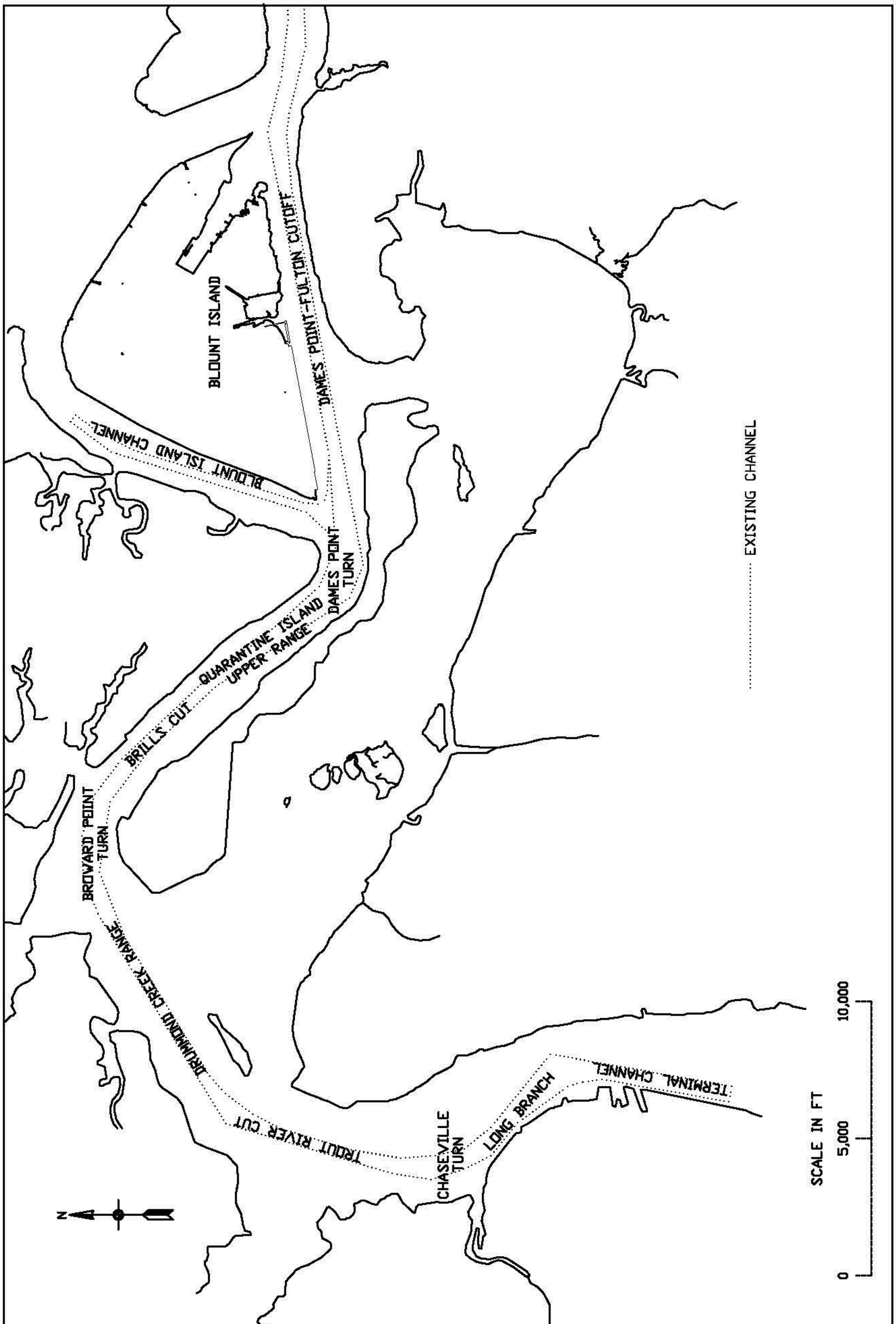


Figure 3. Saint Johns River - Inset 2

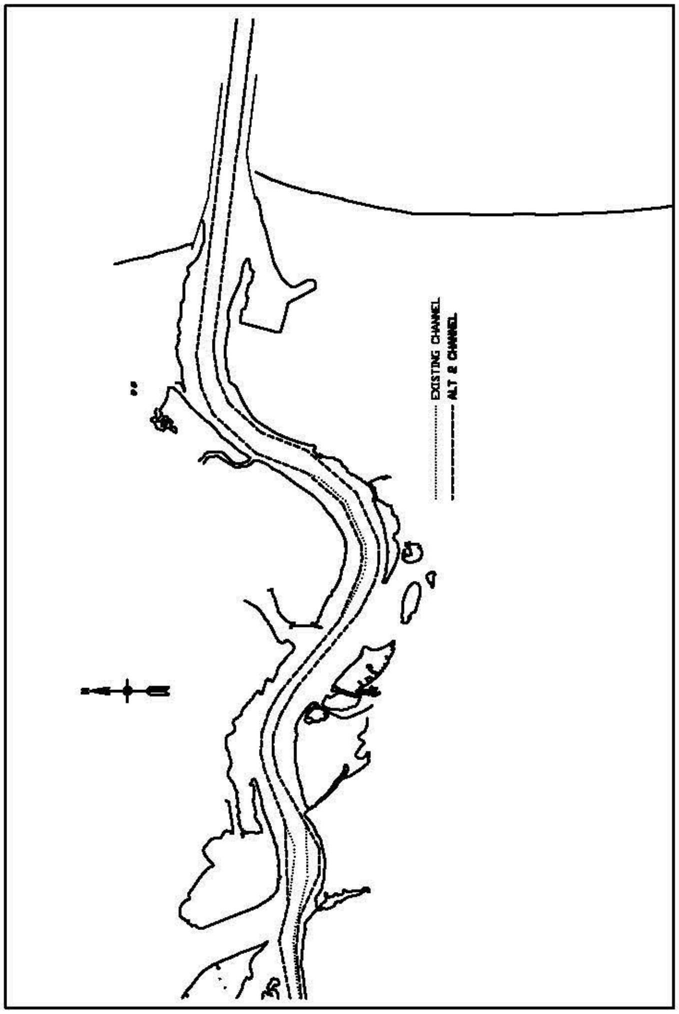


Figure 4 Alt 2 Channel - Inset 1

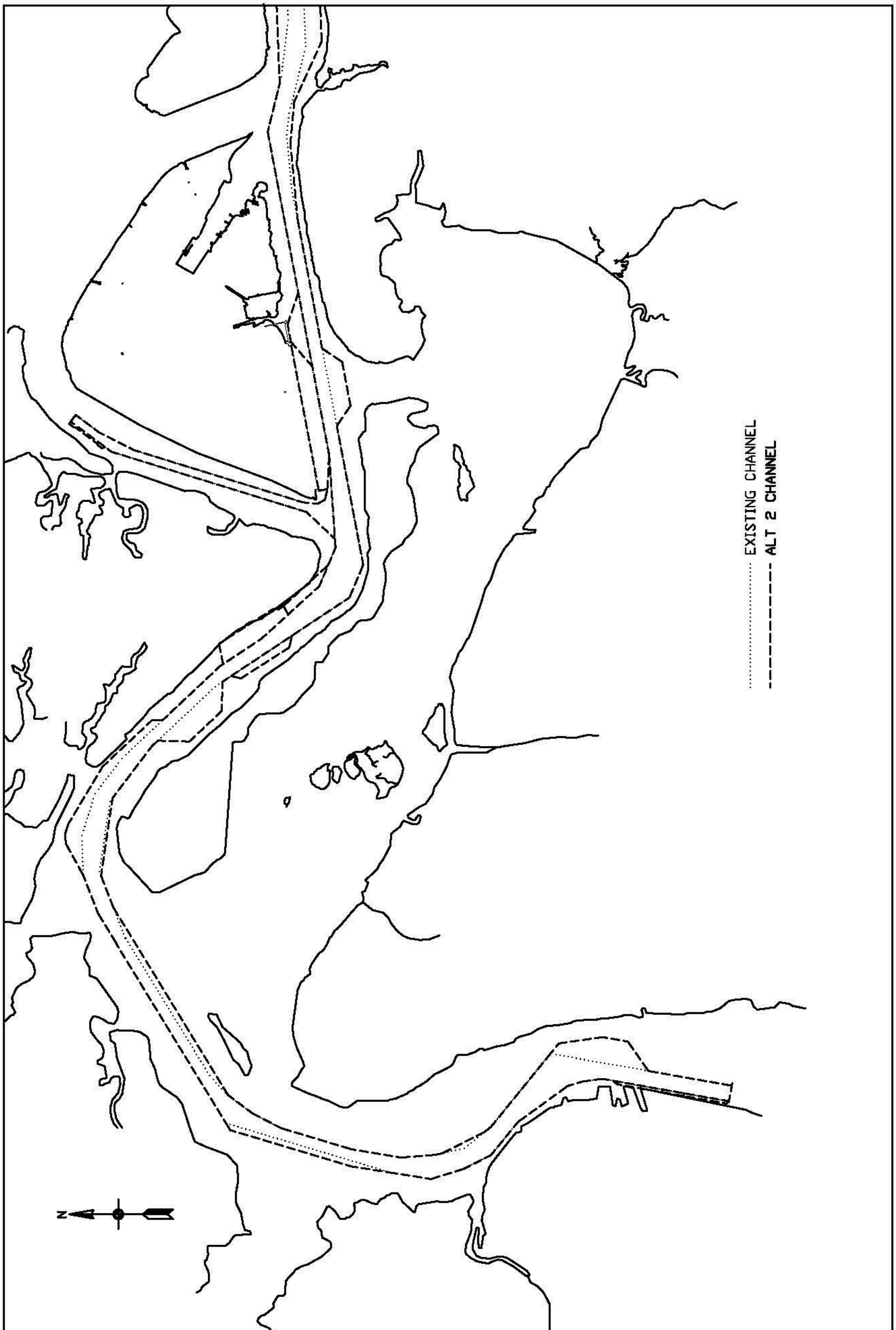


Figure 5 Alt 2 Channel - Inset 2

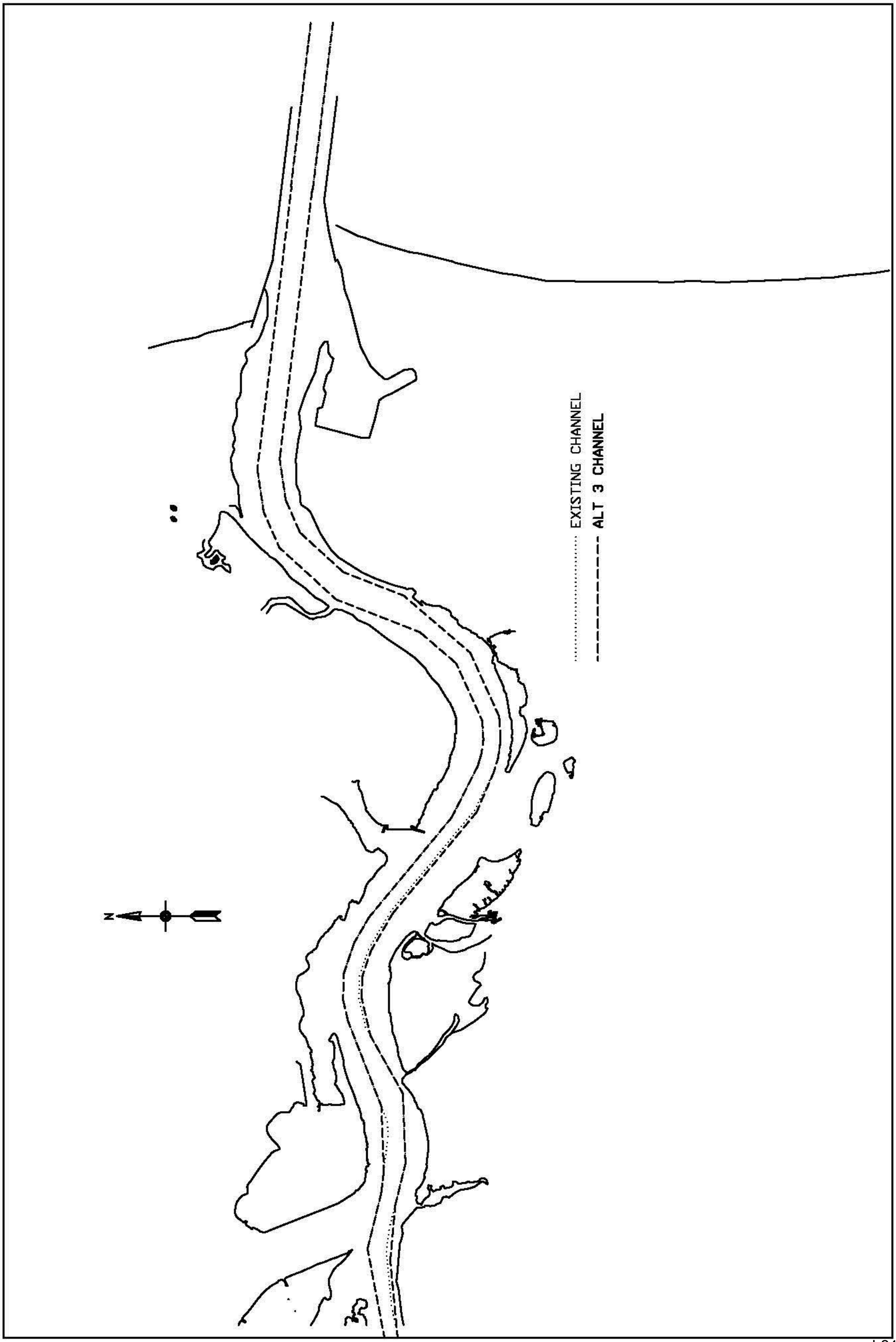


Figure 6 Alt 3 Channel - Inset 1

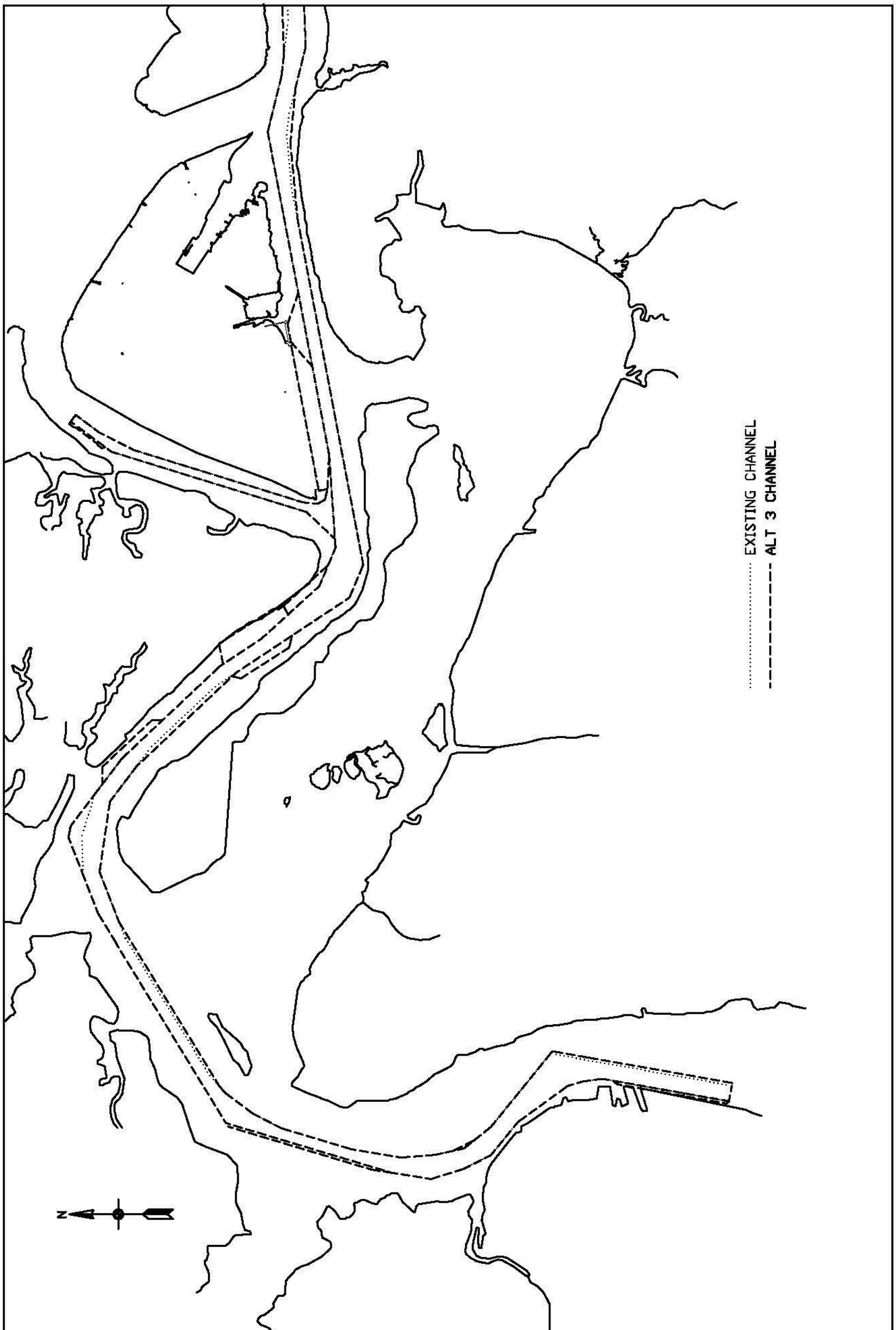


Figure 7 Alt 3 Channel - Inset 2

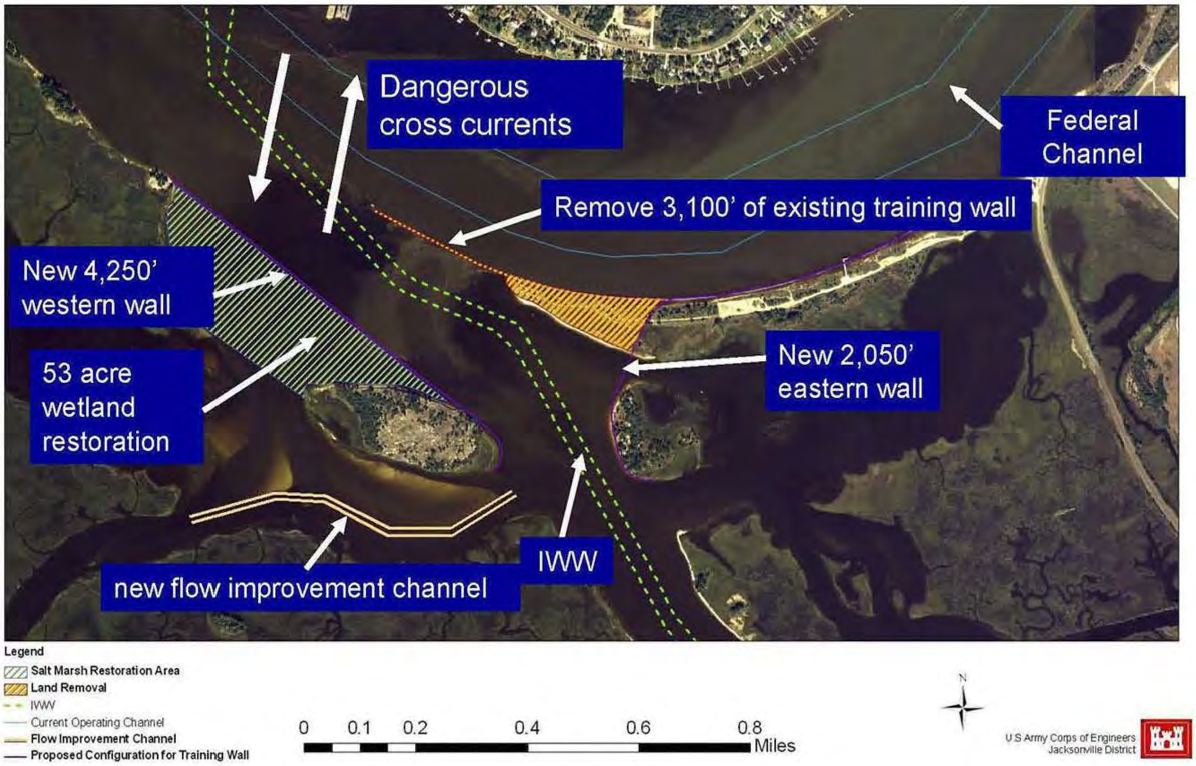


Figure 8. Reconfigured Mile Point Training Wall and Flow Improvement Channel

Figure 9. Pilot operating Simulator

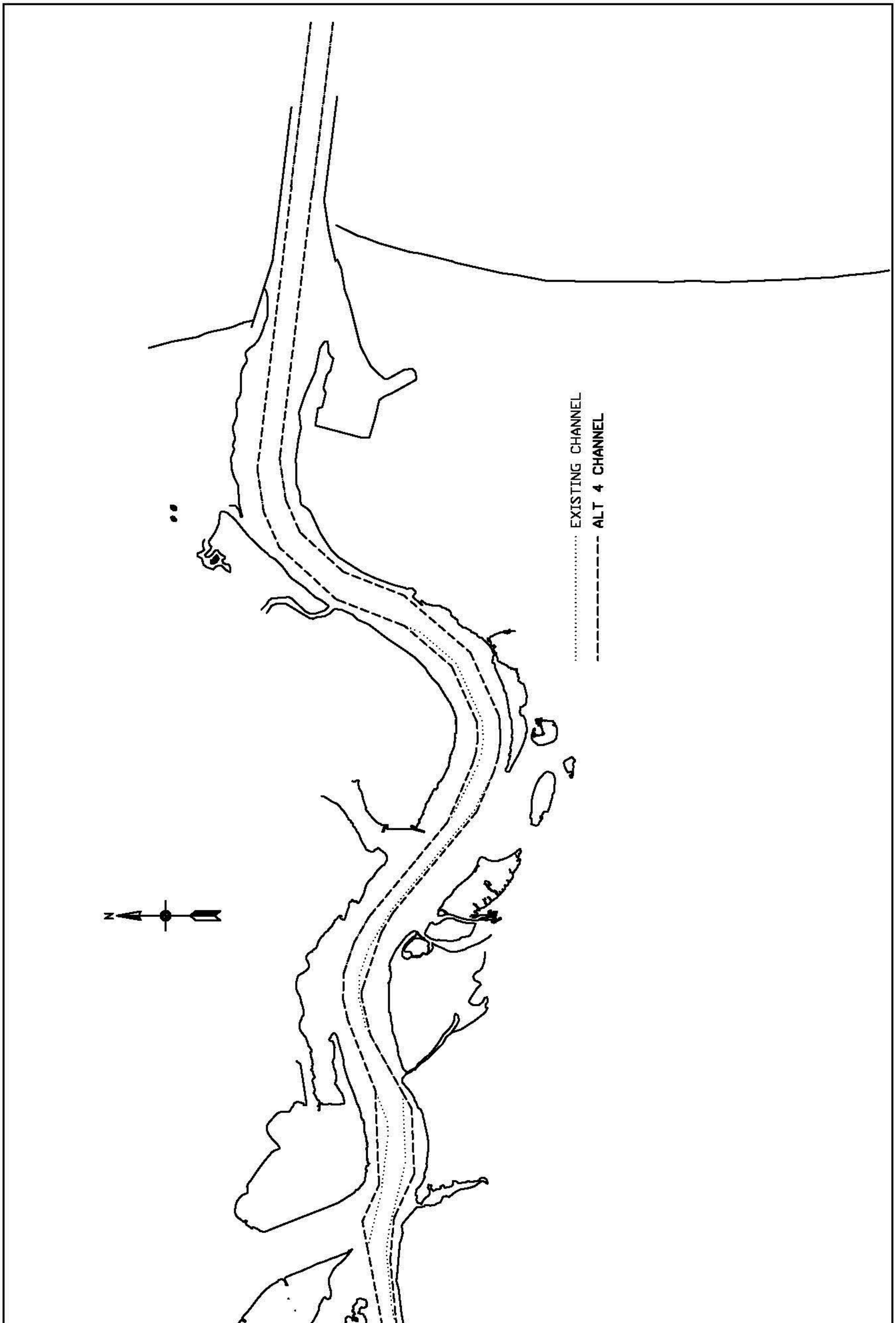


Figure 10 Alt 4 Channel - Inset 1

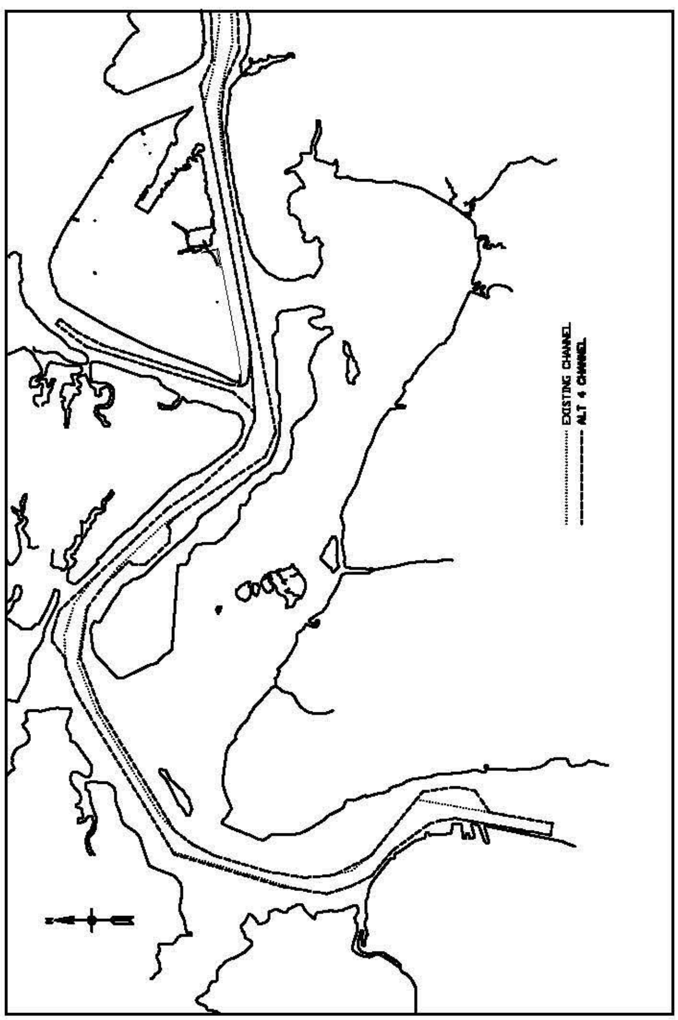


Figure 11 Alt 4 Channel – Inset 1

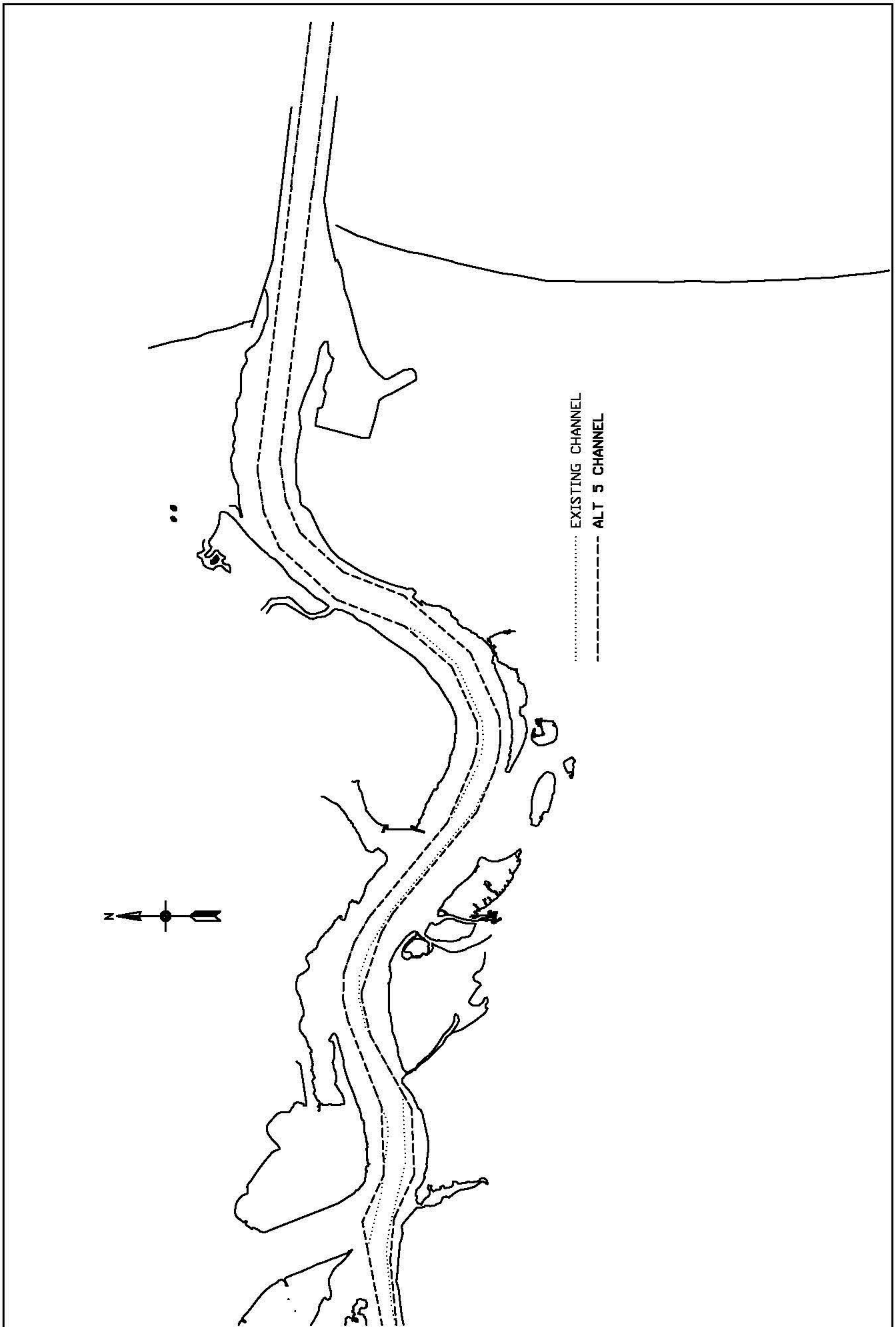


Figure 12 Alt 5 Channel - Inset 1

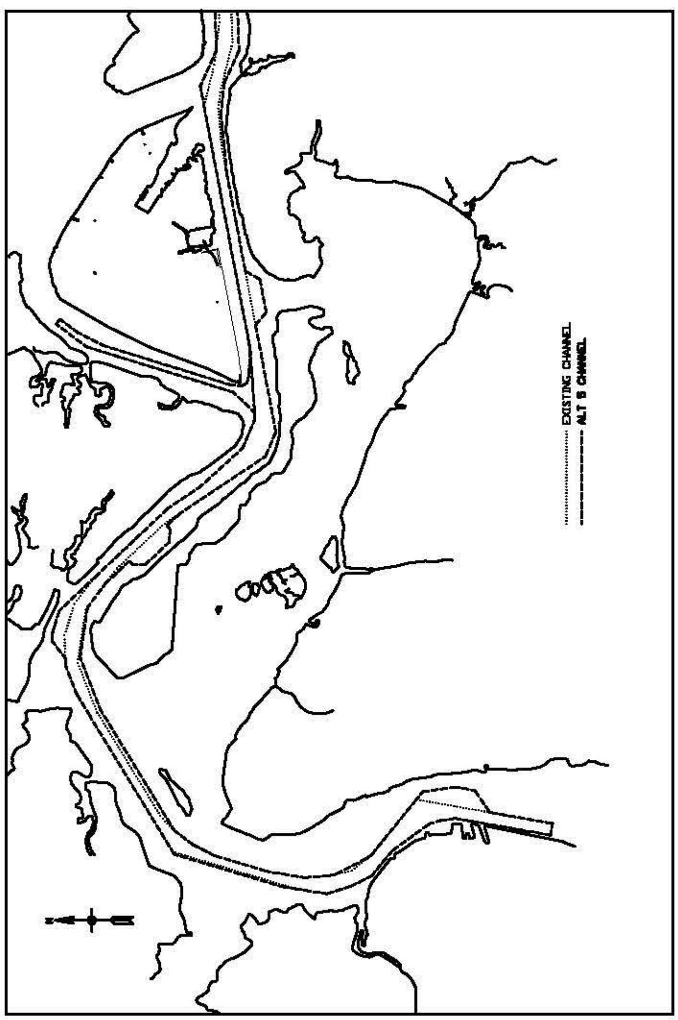


Figure 13 Alt 5 Channel - Inset 1

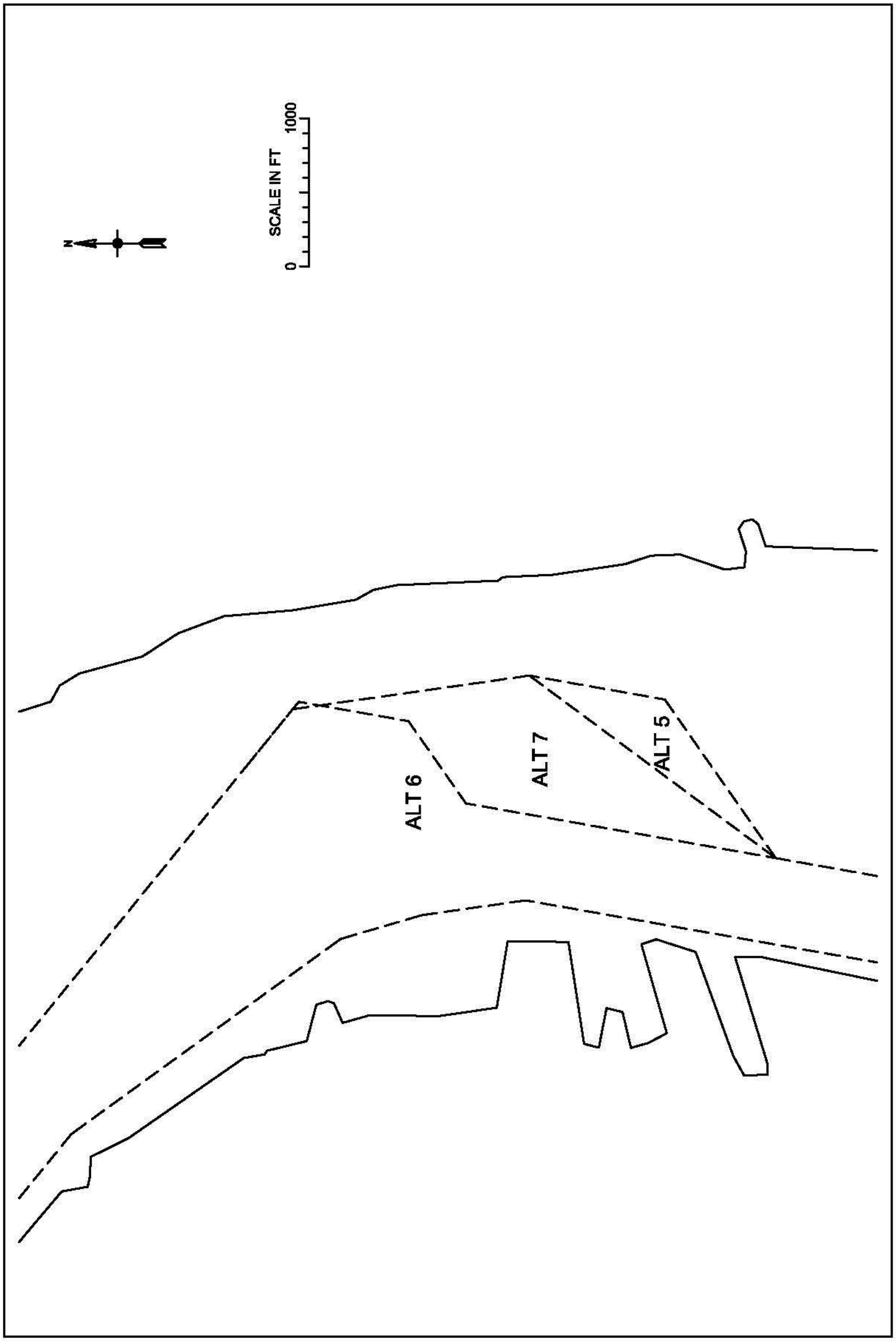


Figure 14. Alts 5, 6, and 7 for TalyRand Basin

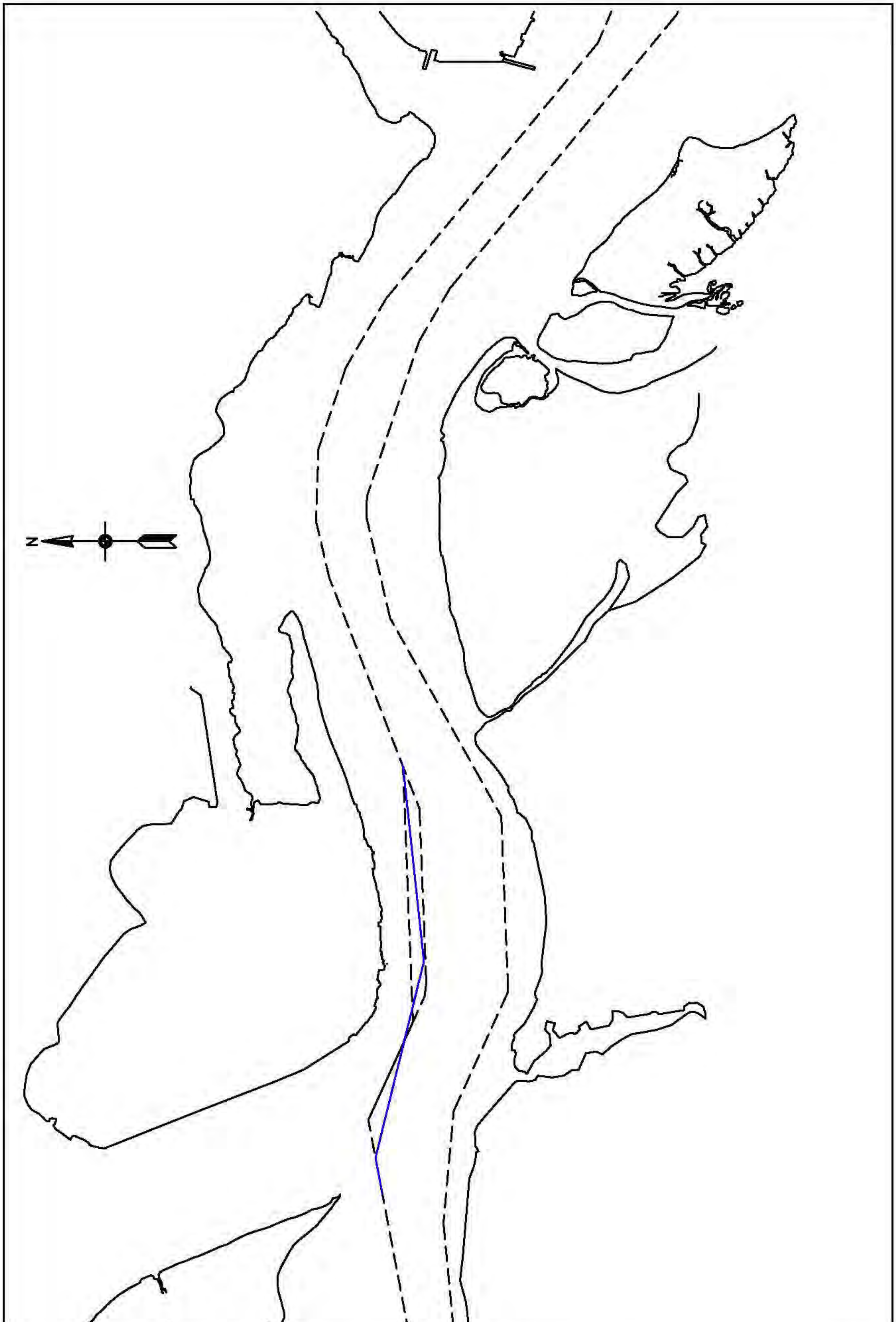


Figure 15. Recommended modifications to simulated channels.

APPENDIX A
WORKING GROUP MEMORANDUM

Working Group with the Pilots post simulation of alternatives 1, 2,3.

September 16th, 2010.

USACE: Steve Conger, Phil Sylvester, Laurel Reichold, Dennis Webb.

St. Johns Bar Pilots: Captain Mons, Brauer, Winegart, and Heath

Objective: to generate a new alternative with MFR of this meeting. Consensus agreement for recommendation of new channel design.

Hanjin Miami Ebb Tide with 2-way Alternative 1:

Mile Point: Bare minimum with every trick on the table, hooked up and hard over is not the ideal, and this was how the pilots had to run through the Mile Point area.

Training wall reach area: outside of the channel on the inbound and outbound. Hard to set up for the turn either direction. No comfortable room to make a safe maneuver, minimally wide.

Cut 42: On south side of the channel, its wide enough, but lots of different legs. Adequate width for one way, but taking up the entire width and a lot of times on the green side of the channel.

Dames point: Turn is very difficult here, simulation appears to maneuver it in the middle of the channel, assuming this is simulated hard over, real life is harder. Not much we can do in this area, channel is as wide as we can get it here.

Brills Cut: two minor turns in this area, cause the vessel to take up a majority of the existing channel width.

Hanjin Miami Flood Tide with 2-way Alternative 1:

Mile Point: length and beam of the Hanjin Miami makes the transit incredibly difficult. Current restriction. Alt 1 is problematic.

Hanjin Miami Ebb Tide with 2-way Alternative 2:

-max widener to the north mile point;

Surge force of two ships passing at Atlantic marine. They don't want to meet near Atlantic marine dock. The ability to adjust speed- timing the meeting and passing in this area is not ideal- not meeting in the sweet spot. Not insurmountable things, but when we talk about narrowing the respective widening. The greatest chance for this to work is to have the combo of mile point and training wall widening (alts 2 and

3), with additional widening in short cut turn. This would elongate the meeting and passing zone for a safe two way.

-max st. john's bluff widener

West side of the reach area, choke point. Don't want to meet in that choke point area. Inbound and Outbound converge at this choke point. Short window for meeting and passing. With the old channel limits, the meeting area would be significantly improved and opened up for a safe. Clear widening is needed to the south (old channel limit area). If the small widener to the north west side- old channel limits would relieve this choke point. Navigation aids are more visible for the outbound vessel. Alt 1 is not do-able. Alt 2: should be modified Alt3: not enough.

Modified alternative 2 with old channel limits NW (38ft channel). stern drags south on the ebb so additional widening to the south into the existing 38 ft. Alternative 3 south increment around buoy 37 needed more width at the choke point- significant for meeting and passing in this area (although lower priority than the widening north and south of the st john's bluff reach area to similar old channel limits), and alternative 2 max widener to the north. We decided to include a simulation of both the mid and max widener in st. john's bluff reach area.

***See drawing for Alt 4 and Alt 5. Alt 5 would be just for short simulation in this area to test the necessity of the northern widening in this area.

Hanjin Miami Flood Tide with 2-way Alternative 2:

- mile point;

Clear from tracks that short cut, training wall, and mile point widening needs to occur for safe meeting and passing in this area. Ebb and flood tide conclusions are consistent in this area.

- st. john's bluff widener

Consistent for ebb and flood as well conclusions.

Hanjin Miami Ebb Tide with 2-way Alternative 3:

Brills Cut: 175' widening to the south. Need to simulate the Brills Cut with the Hanjin Miami ship.

Bottleneck at buoy 51- would make it unsafe in lack of widening.

Would two Hanjin's Miami mtg in this area? Answer was: not likely. The more likely scenario is a post panamax meeting a panamax in this area. This is what we actually simulated. The passing distance was comfortable. This widening would be essential for unrestricted meeting and passing. Political issues with widening around buoy 51 involving that trapac turning basin, so despite the bottleneck in this area and the desire for a little more width, this would go into a private turning basin- for which we cannot guarantee maintenance. Plan to re-simulate the outbound and inbound of panamax and hanjin in the brills cut with 2-way of panamax and Hanjin Miami.

Generic Containership (panamax) Ebb Tide with Alternative 1:

Current widths are maxed out, and meeting and passing never in trout, and hardly ever in Drummond Creek. Alternative 1: will not work for meeting and passing.

-Broward Pt: right at buoy's 55 and buoy 57 widening to the south might help getting around the broward point turn in around to set up for the turn. But no widening to the north. Widening to the south from buoy 57 to 59. Modification to Alt 2.

Generic Containership (panamax) Flood Tide with Alternative 1:

Outside of the channel transiting from Drummond into Trout River on the inbound- rounding of the current.

Generic Containership (panamax) Ebb/Flood Tide with Alternative 2:

-Broward Pt: right at buoy's 55 and buoy 57 widening to the south might help getting around the broward point turn in around to set up for the turn. But no widening to the north needed. Widening to the south from buoy 57 to 59. Modification to Alt 2.

Drummond 200' widener necessary. Speed of vessel is limited to 6 knot- cannot slow down and speed up, make location of meeting extremely variable- thus widening increment in Drummond Creek cannot be shortened.

Collision 15 years ago in this area.

-Trout River Creek: Max widening will not enable 2-way in this region (ever). The mid widening alternative, however would be necessary for safe one-way. And for setting up for two-way for the Drummond Creek range. This would also allow two smaller ships to meet and pass here.

-Chaseville Turn: Max widener in this area needed. The overwhelming consensus amonf he pilots is that the channel is not wide enough at Buoy 67 now. Mid widener in this area not adequate (flood is when the issues are) sets the vessel on the green side of the channel.

Generic Containership (panamax) Flood Tide with Alternative 3:

-Drummond Creek: Ship interaction for a two-way was not an adequate safety margin distance between ships for Drummond Creek.

- trout River: mid widening necessary for setting up for two way in Drummond Creek, and allow smaller ships to meet and pass here.

mid widener in this area not adequate (flood is when the issues are) sets the vessel on the green side of the channel.

-Chaseville Turn: mid widener in this area not adequate (flood is when the issues are) sets the vessel on the green side of the channel.

Generic Containership (panamax) Ebb Tide with Alternative 3:

-Drummond Creek: mid widening: not adequate for two-way traffic. Consistent with flood tide conclusions.

-trout River: same conclusion as flood tide- the mid is adequate (but would never be two way traffic).

-Chaseville Turn: mid widener in this area not adequate (flood is when the issues are) sets the vessel on the green side of the channel.

Alternative 4: To be tested at the simulator:

Mile Point max widener to the north –alt 2

Training wall reach area widening to the south- alt 3

Additional short cut turn widening to the south(buoy 25 and 27)- additional- comparable to mile point area widener ~825'. Look at increase of 250' in short cut turn. This would be a cutoff having a maximum. Delaying turn because of buoy 25, so widener in this area is the addition.

Previous 38' limits nw side of st. johns bluff reach- additional

Max widener st johns bluff to the north (400')- alt 2

Additional 400' increment to the south within 38' previously authorized project limits- additional

Southern increment west of st johns bluff widening- alt 2

Brills cut widening- alt 3

Additional broward point buoys 57 to 59 southern widener- additional

Drummond creek maximum widener- alt 2

Trout river cut mid widener- alt 3

Maximum chaseville turn widener- alt 2

Alternative 5: To be tested at the simulator: just st johns bluff reach area for gaming

Previous 38’ limits nw side of st. johns bluff reach- additional

Mid widener st johns bluff to the north (400’)- alt 2

Additional 400’ increment to the south within 38’ previously authorized project limits- additional

Southern increment west of st johns bluff widening- alt 2

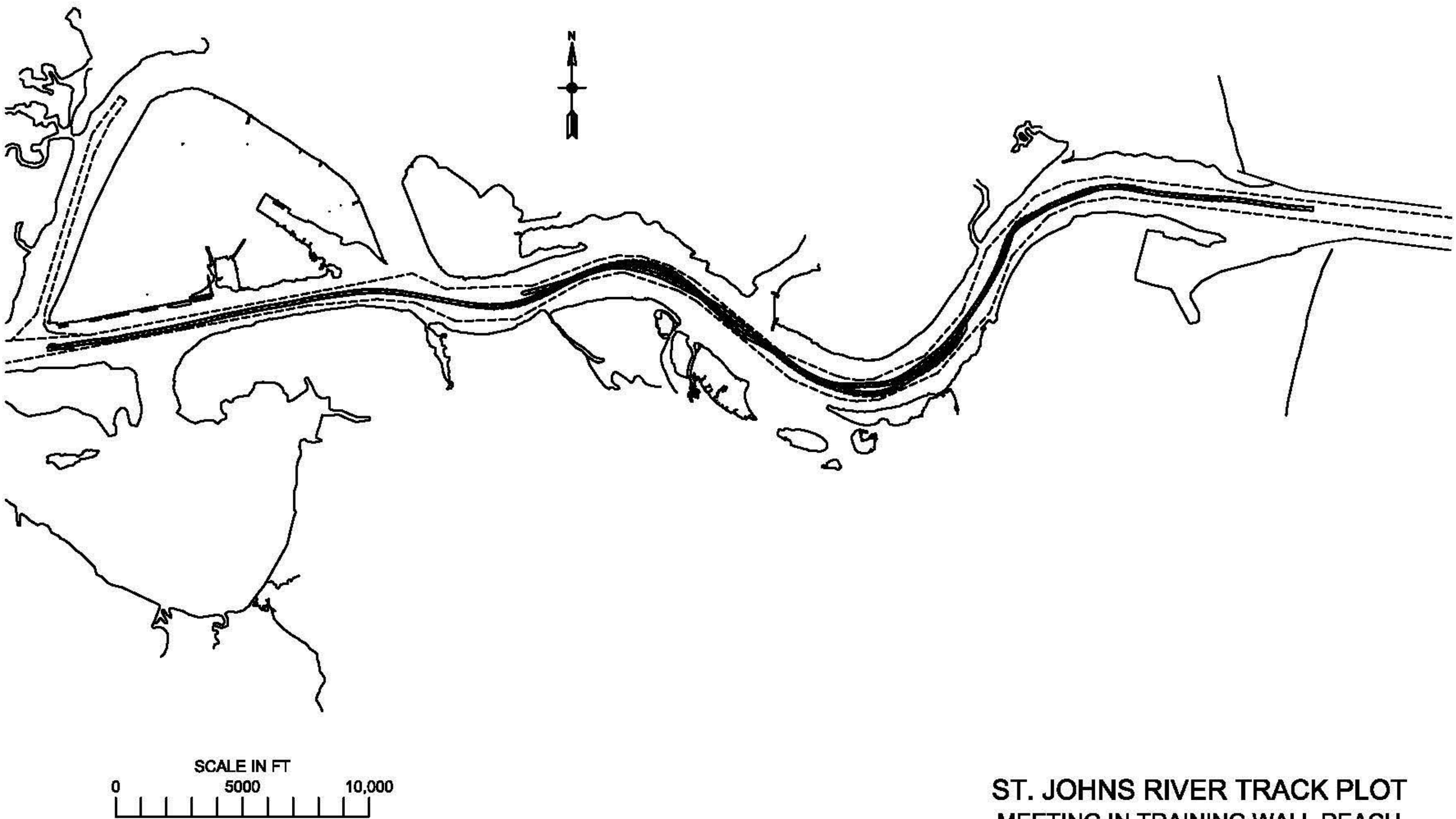
Parting thought: quantification of delay impacted. Frequencies: if its one way traffic- limiting the number of ships that can call the port over a given 24 hr period. – 12 ships a day (2 hour).

Two-way traffic: then we have X amount of ships that can call. With three meeting and passing areas, unrestricted 24/7. Don’t want to think of the areas broken up. the delays impacted by having two out of the three mtg and passing areas is not quantifiable. Taking away one of these areas would decrease the benefit of the other two. They are needed in combination to make a 24/7 unrestricted channel for increased growth.

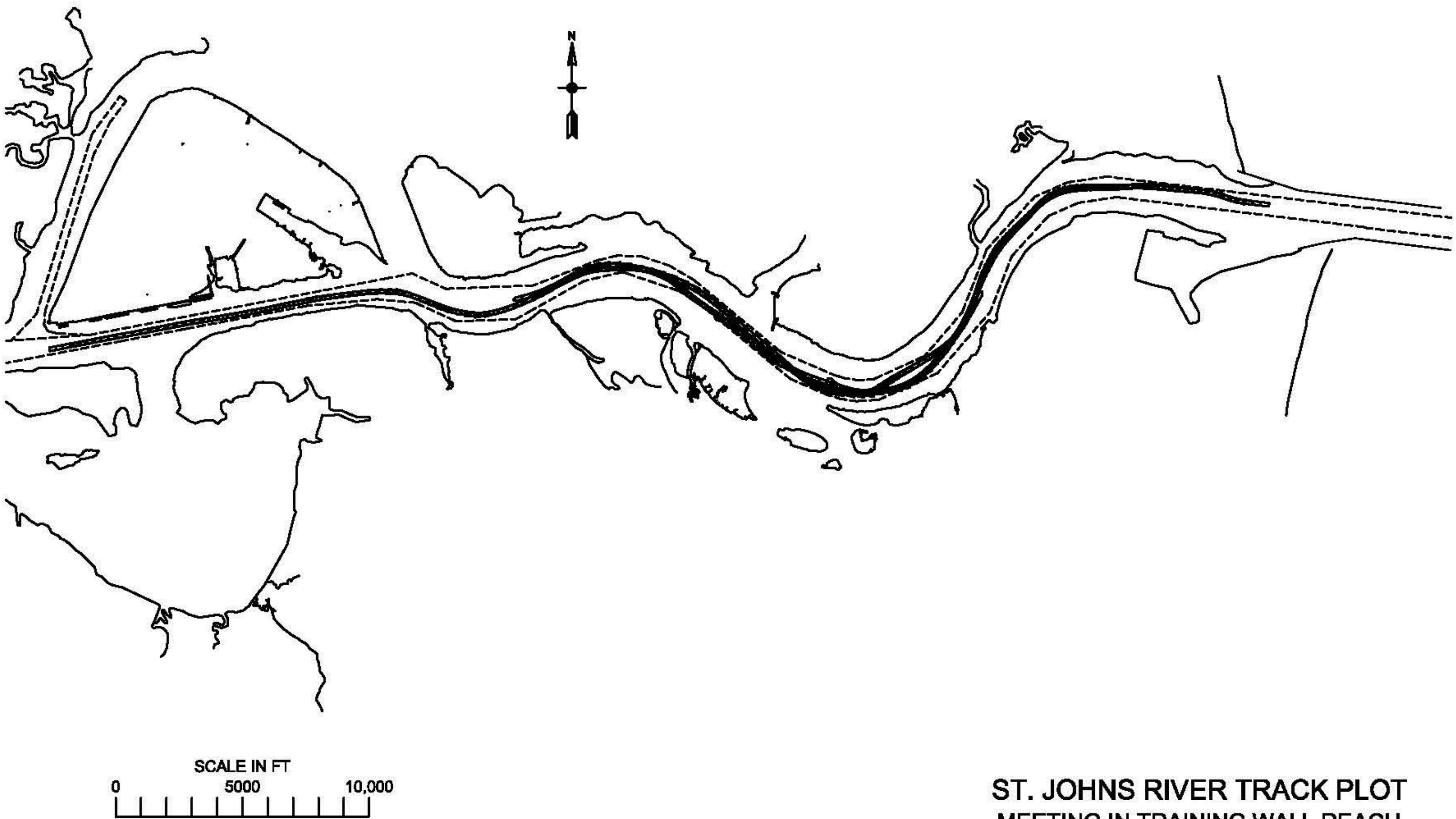
Two weeks of testing with the harbor pilots. Sooner for a good week- the better.

APPENDIX B
PLATES

PLATE 1



ST. JOHNS RIVER TRACK PLOT
MEETING IN TRAINING WALL REACH
INBOUND SHIP - HANJIN MIAMI
OUTBOUND SHIP - HANJIN MIAMI
EBB TIDE - ALT 4 CHANNEL



ST. JOHNS RIVER TRACK PLOT
MEETING IN TRAINING WALL REACH
INBOUND SHIP - HANJIN MIAMI
OUTBOUND SHIP - HANJIN MIAMI
FLOOD TIDE - ALT 4 CHANNEL

PLATE 2

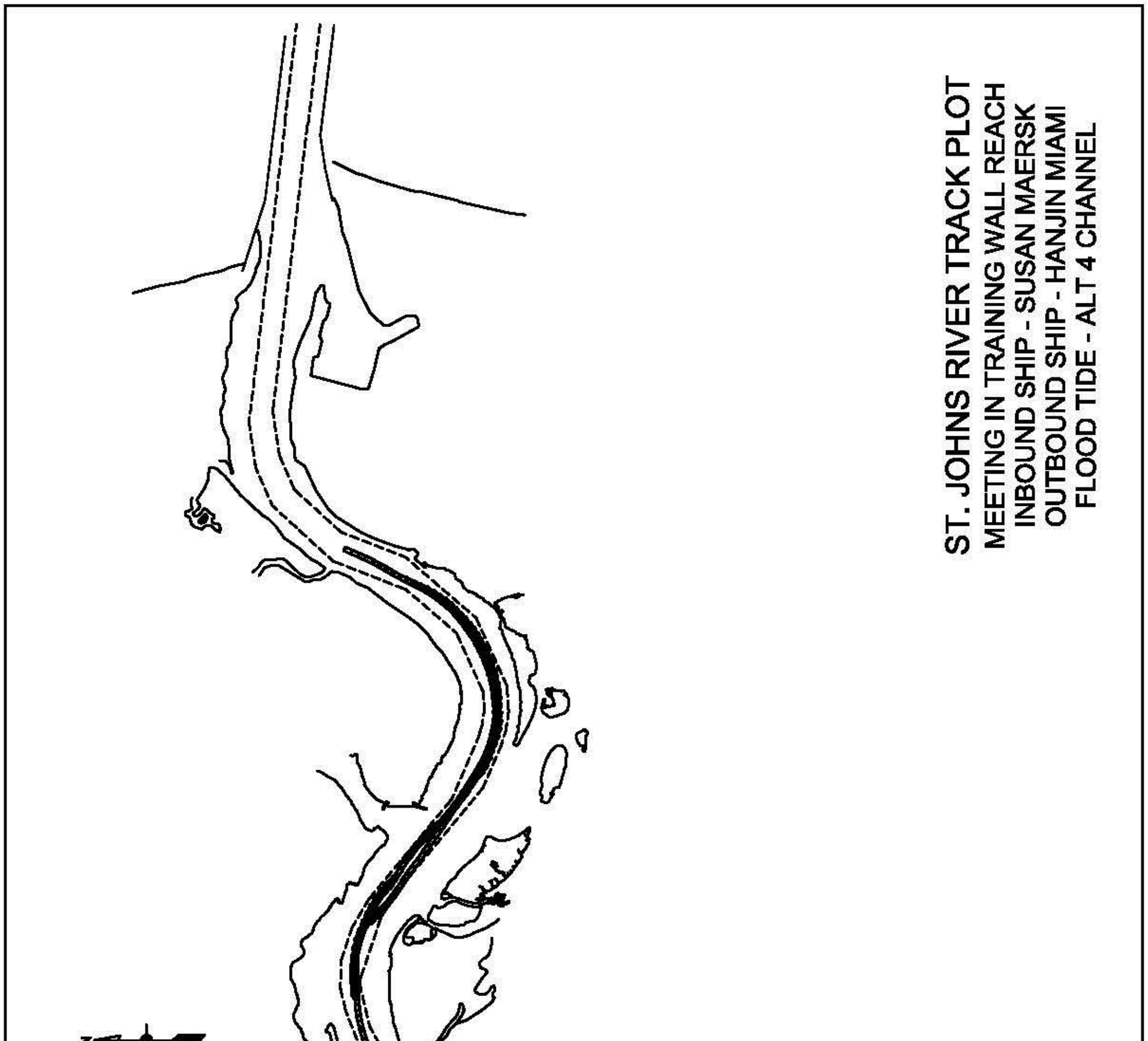

ST. JOHNS RIVER TRACK PLOT
MEETING IN TRAINING WALL REACH
INBOUND SHIP - SUSAN MAERSK
OUTBOUND SHIP - HANJIN MIAMI
FLOOD TIDE - ALT 4 CHANNEL
SCALE IN FT
0
5000
10,000
N

PLATE 3

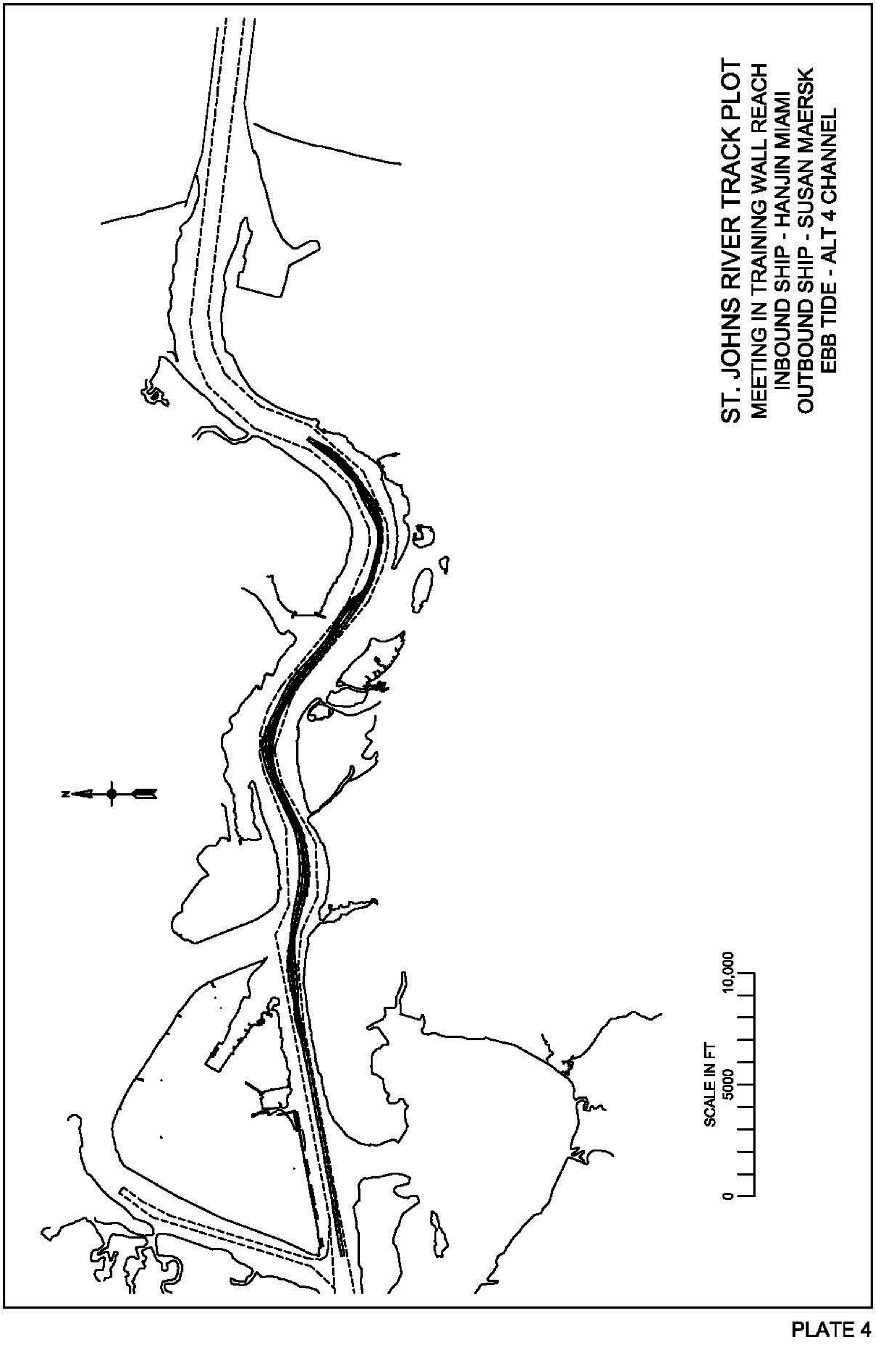
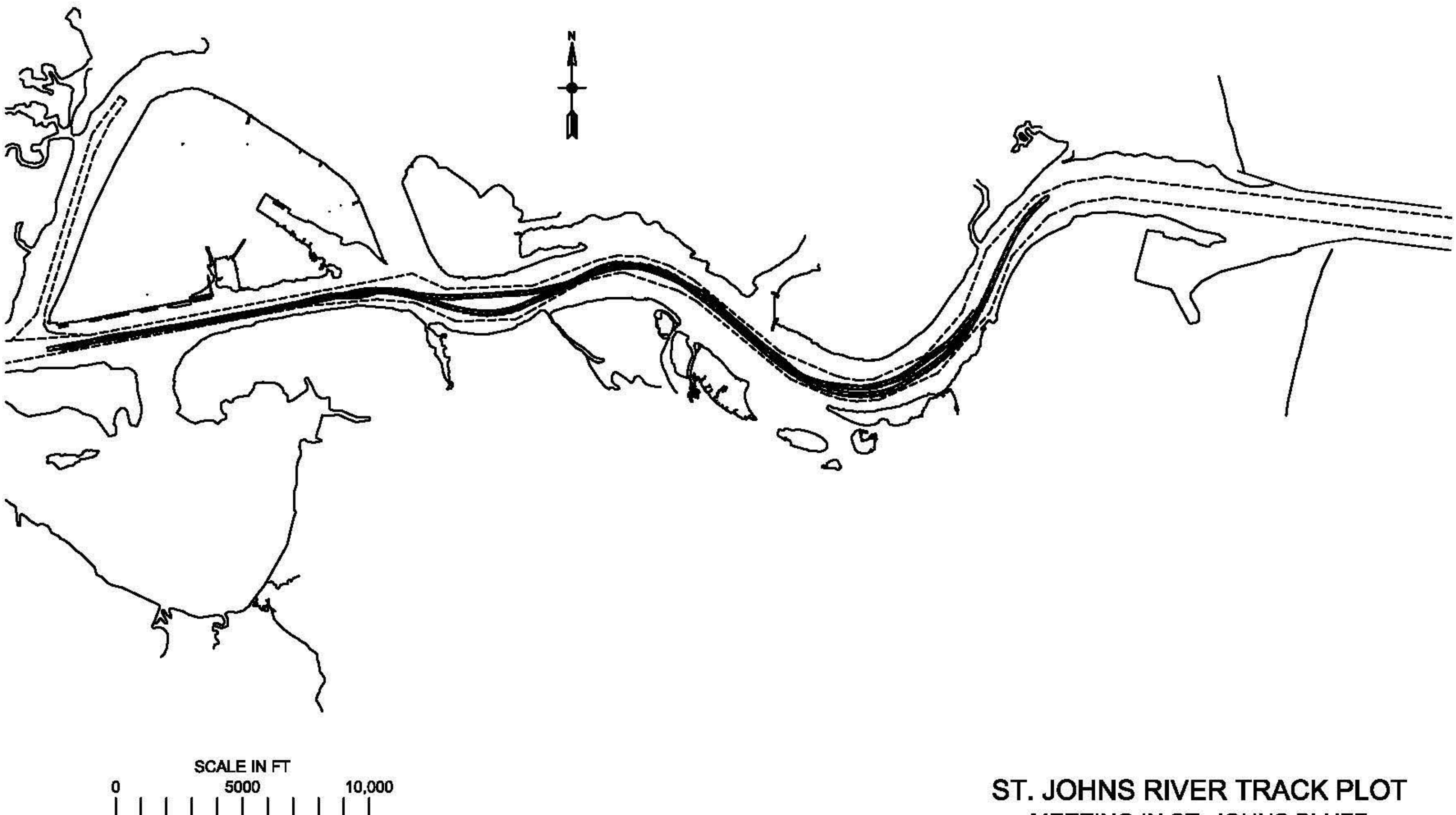

ST. JOHNS RIVER TRACK PLOT
MEETING IN TRAINING WALL REACH
INBOUND SHIP - HANJIN MIAMI
OUTBOUND SHIP - SUSAN MAERSK
EBB TIDE - ALT 4 CHANNEL
SCALE IN FT
0
5000
10,000
N

PLATE 4

PLATE 5



ST. JOHNS RIVER TRACK PLOT
MEETING IN ST. JOHNS BLUFF
INBOUND SHIP - HANJIN MIAMI
OUTBOUND SHIP - HANJIN MIAMI
EBB TIDE - ALT 4 CHANNEL

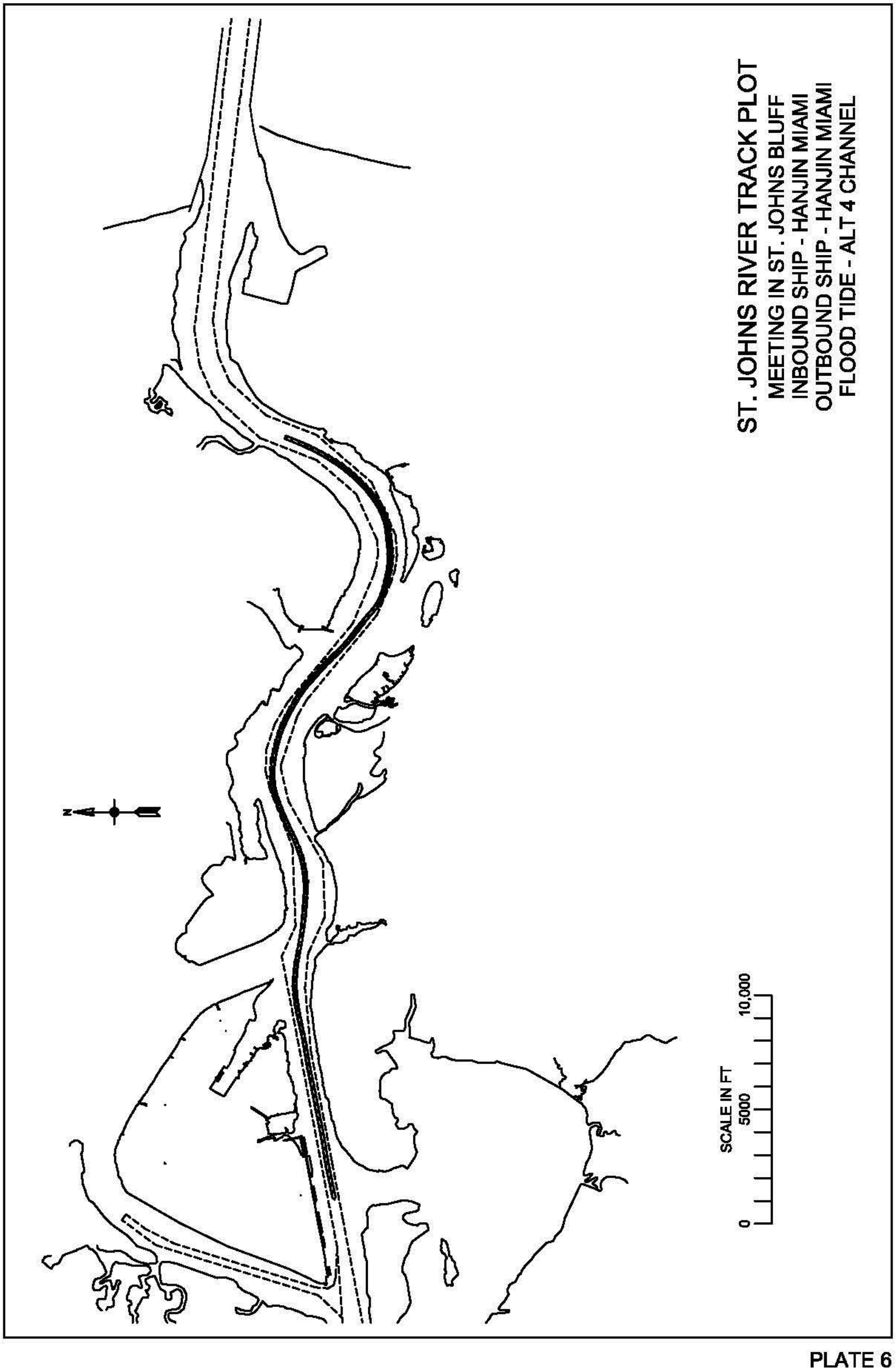

ST. JOHNS RIVER TRACK PLOT
MEETING IN ST. JOHNS BLUFF
INBOUND SHIP - HANJIN MIAMI
OUTBOUND SHIP - HANJIN MIAMI
FLOOD TIDE - ALT 4 CHANNEL
SCALE IN FT
0
5000
10,000

PLATE 6

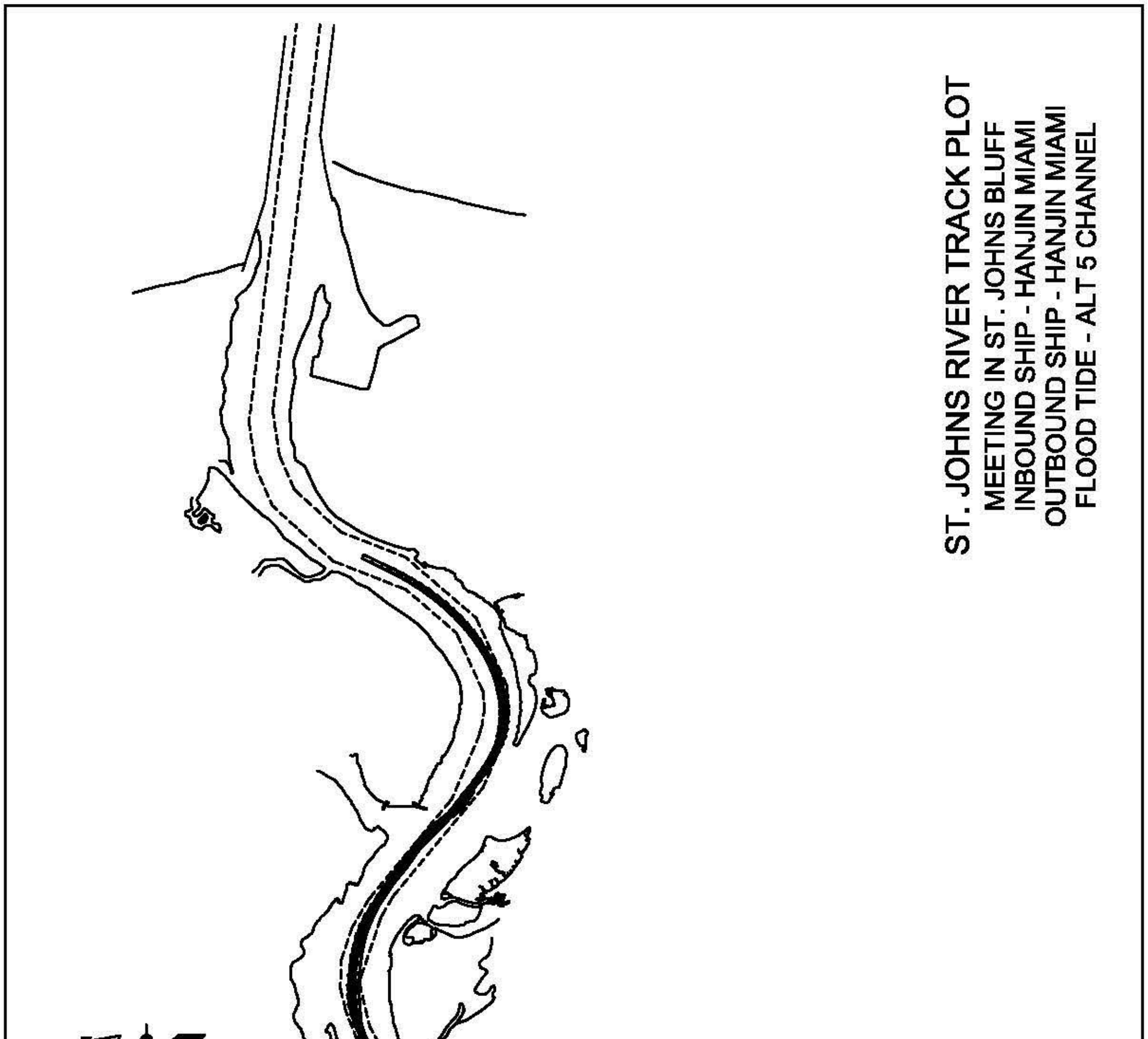

ST. JOHNS RIVER TRACK PLOT
MEETING IN ST. JOHNS BLUFF
INBOUND SHIP - HANJIN MIAMI
OUTBOUND SHIP - HANJIN MIAMI
FLOOD TIDE - ALT 5 CHANNEL
SCALE IN FT
0
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PLATE 7

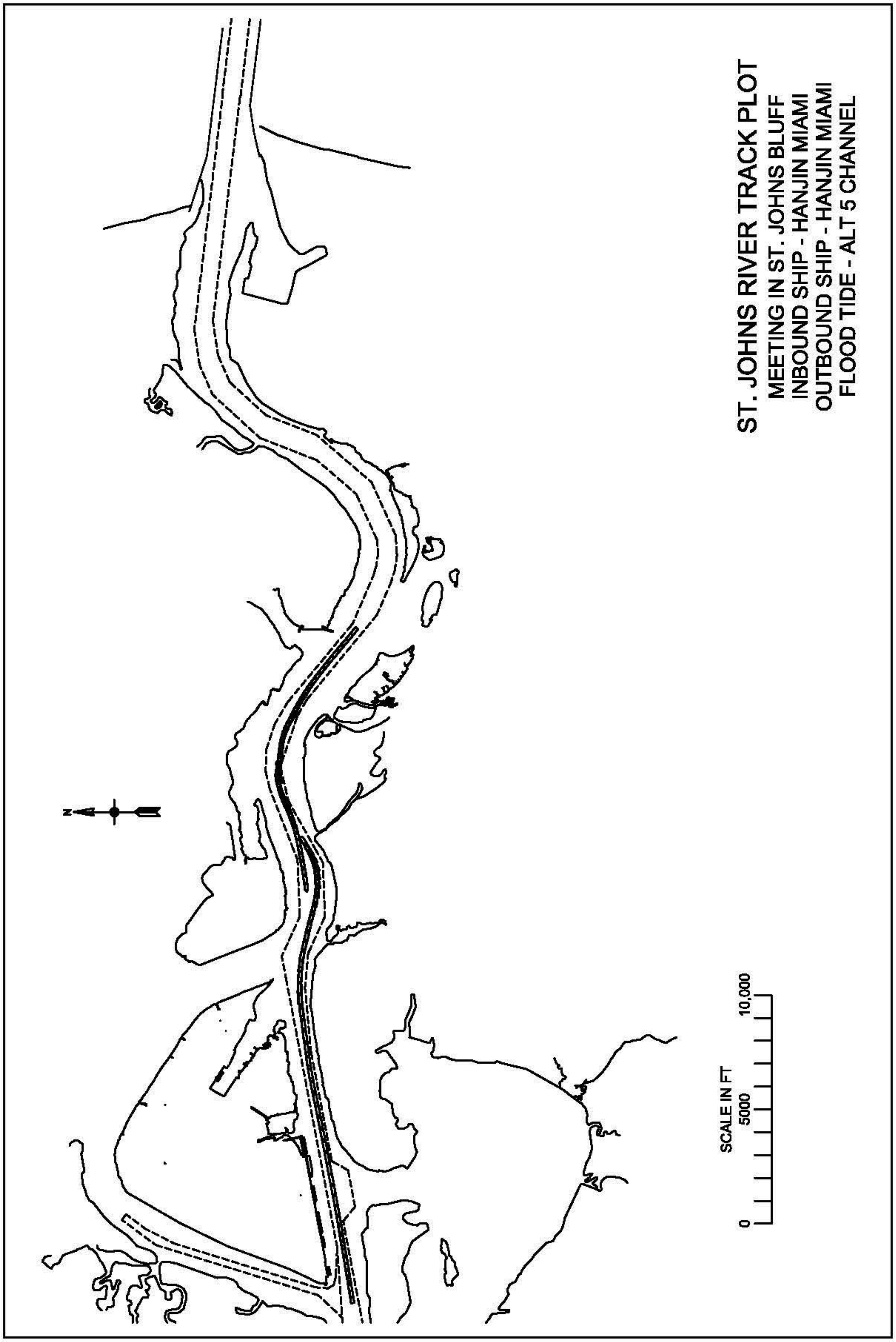
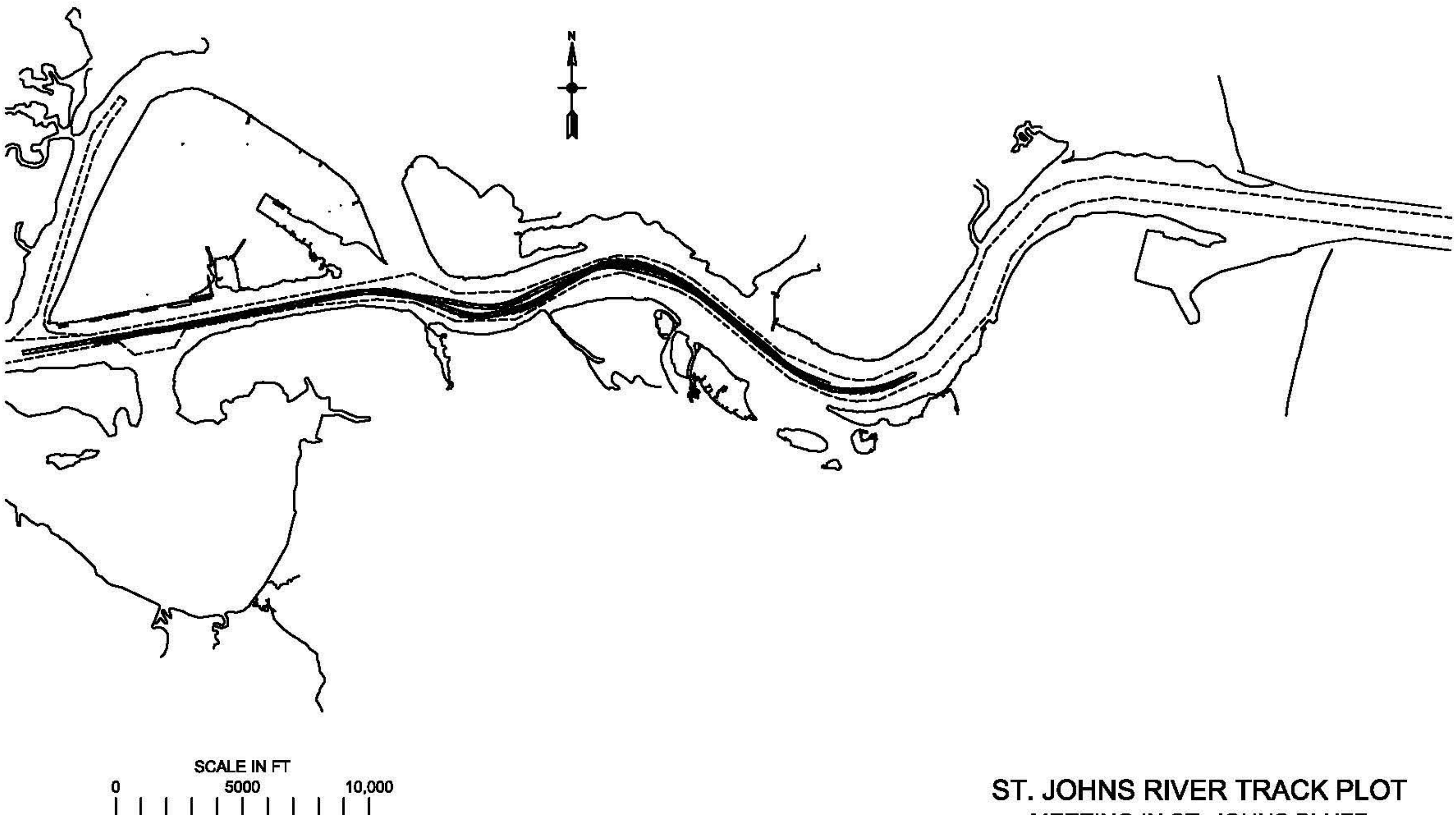
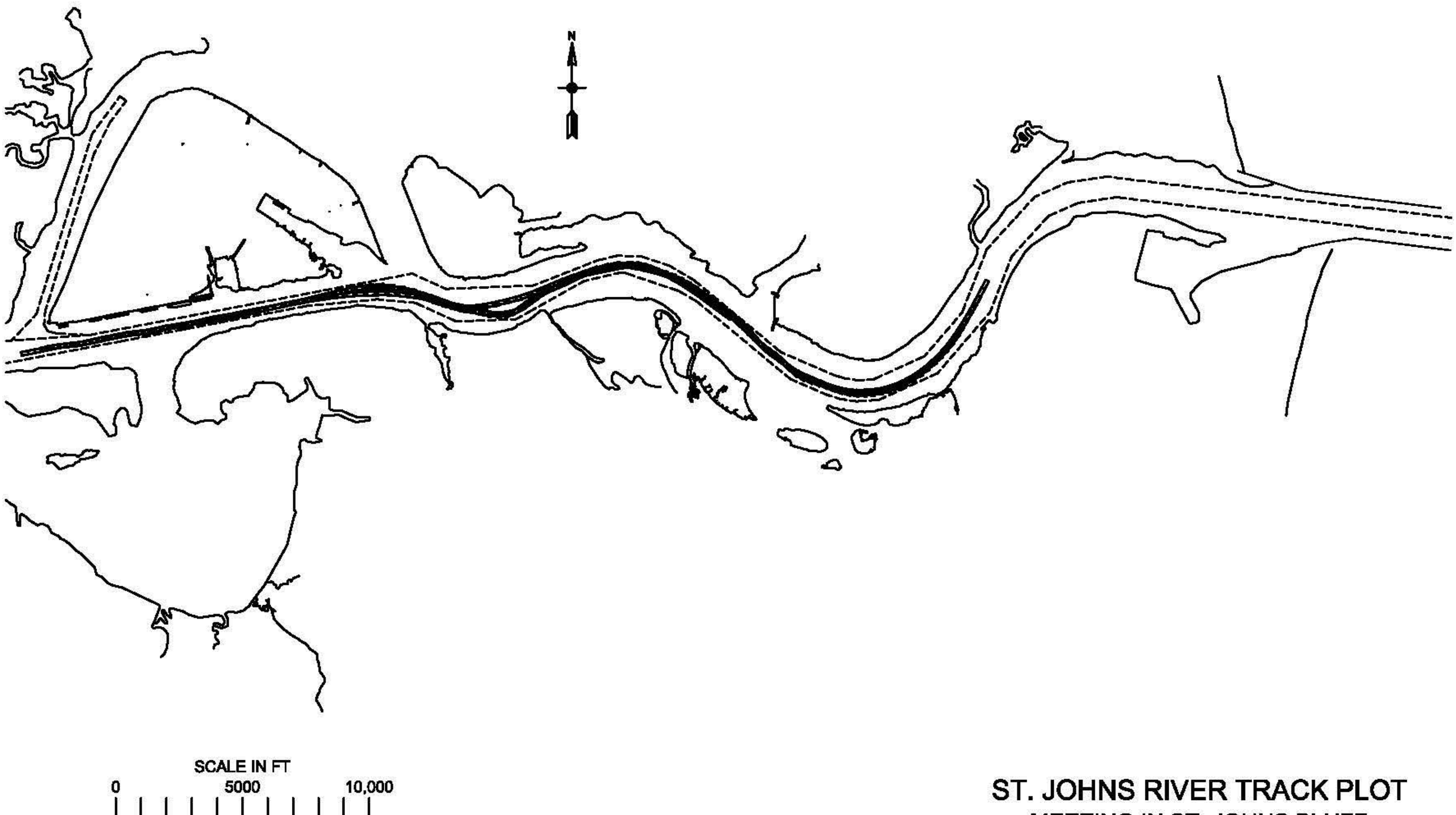

ST. JOHNS RIVER TRACK PLOT
MEETING IN ST. JOHNS BLUFF
INBOUND SHIP - HANJIN MIAMI
OUTBOUND SHIP - HANJIN MIAMI
FLOOD TIDE - ALT 5 CHANNEL
SCALE IN FT
0
5000
10,000
N

PLATE 8



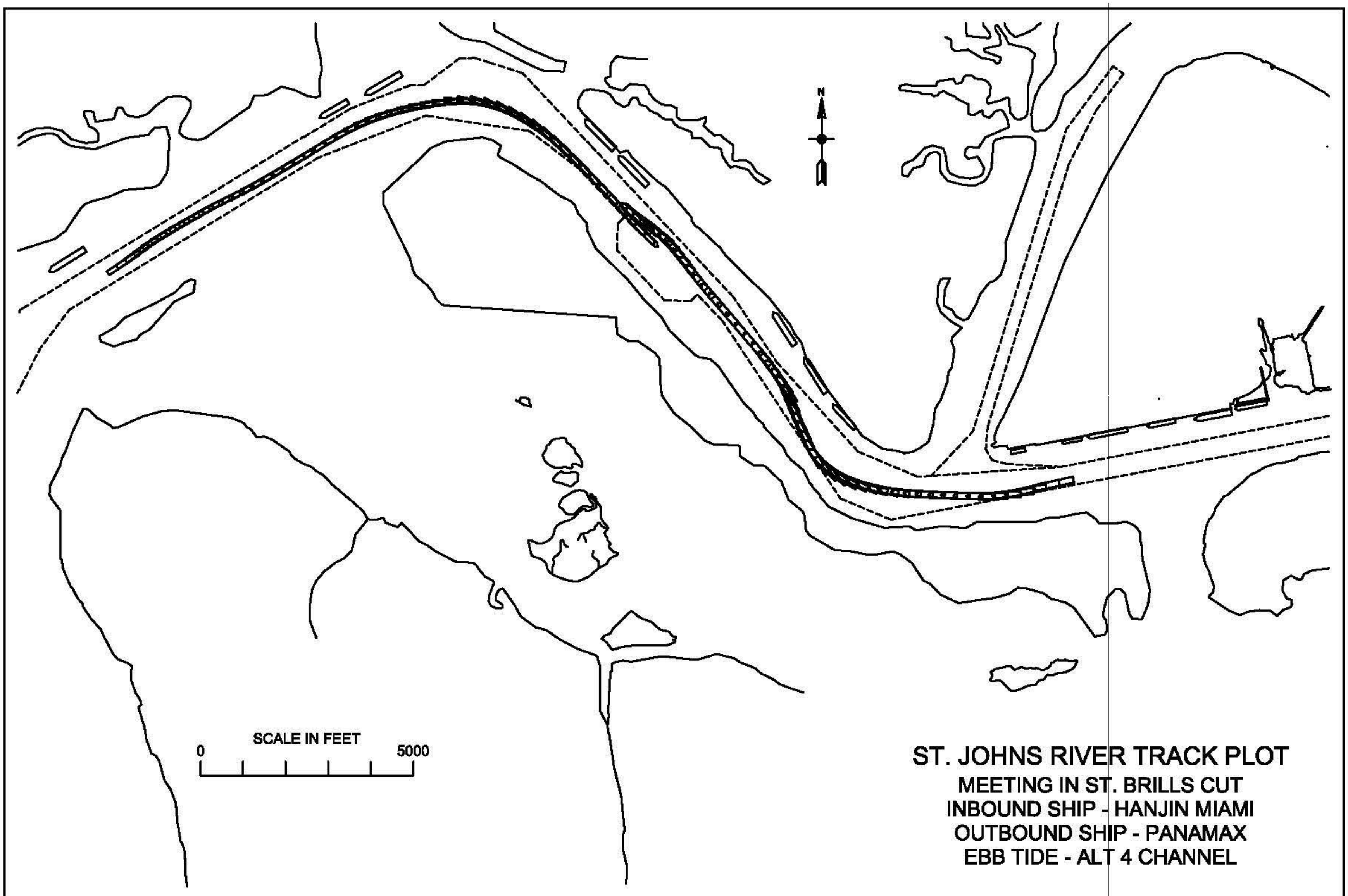
ST. JOHNS RIVER TRACK PLOT

MEETING IN ST. JOHNS BLUFF
INBOUND SHIP - HANJIN MIAMI
OUTBOUND SHIP - SUSAN MAERSK
EBB TIDE - ALT 5 CHANNEL



ST. JOHNS RIVER TRACK PLOT
MEETING IN ST. JOHNS BLUFF
INBOUND SHIP - SUSAN MAERSK
OUTBOUND SHIP - HANJIN MAIMI
FLOOD TIDE - ALT 4 CHANNEL

PLATE 10


N
SCALE IN FEET
0
5000
ST. JOHNS RIVER TRACK PLOT
MEETING IN ST. BRILLS CUT
INBOUND SHIP - HANJIN MIAMI
OUTBOUND SHIP - PANAMAX
EBB TIDE - ALT 4 CHANNEL

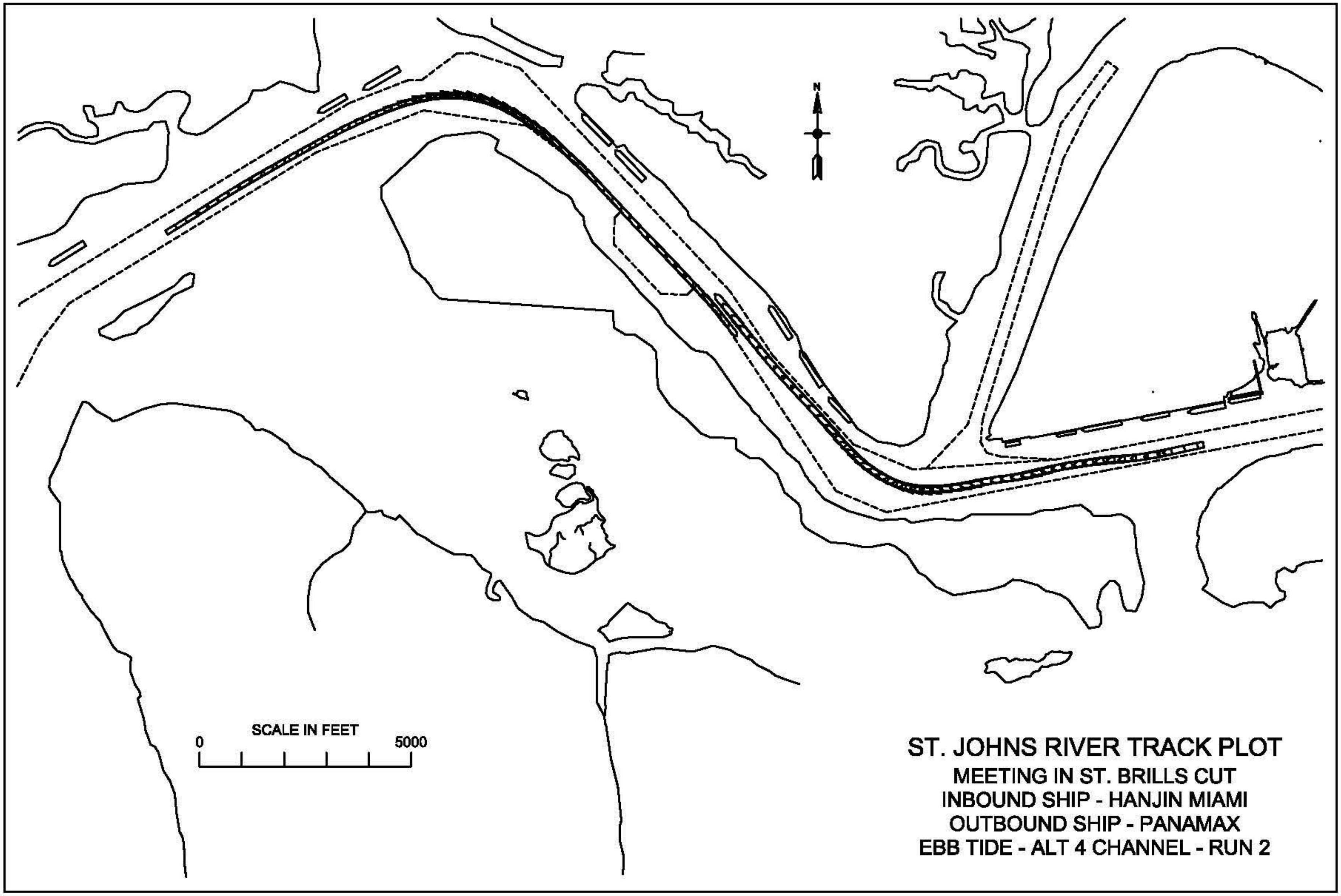

N
SCALE IN FEET
0
5000
ST. JOHNS RIVER TRACK PLOT
MEETING IN ST. BRILLS CUT
INBOUND SHIP - HANJIN MIAMI
OUTBOUND SHIP - PANAMAX
EBB TIDE - ALT 4 CHANNEL - RUN 2

PLATE 12

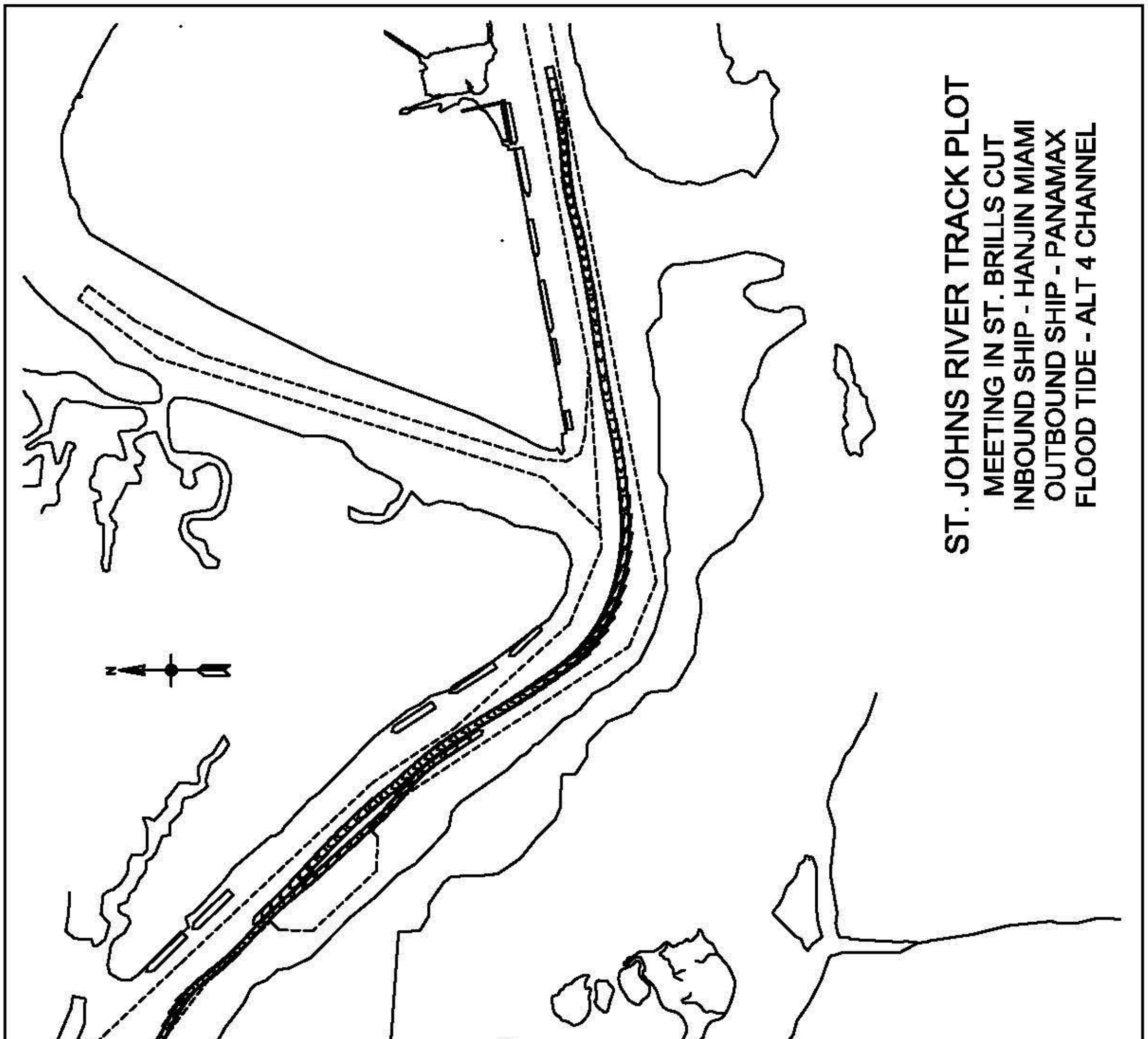

ST. JOHNS RIVER TRACK PLOT
MEETING IN ST. BRILLS CUT
INBOUND SHIP - HANJIN MIAMI
OUTBOUND SHIP - PANAMAX
FLOOD TIDE - ALT 4 CHANNEL
SCALE IN FEET
0
5000
N

PLATE 13

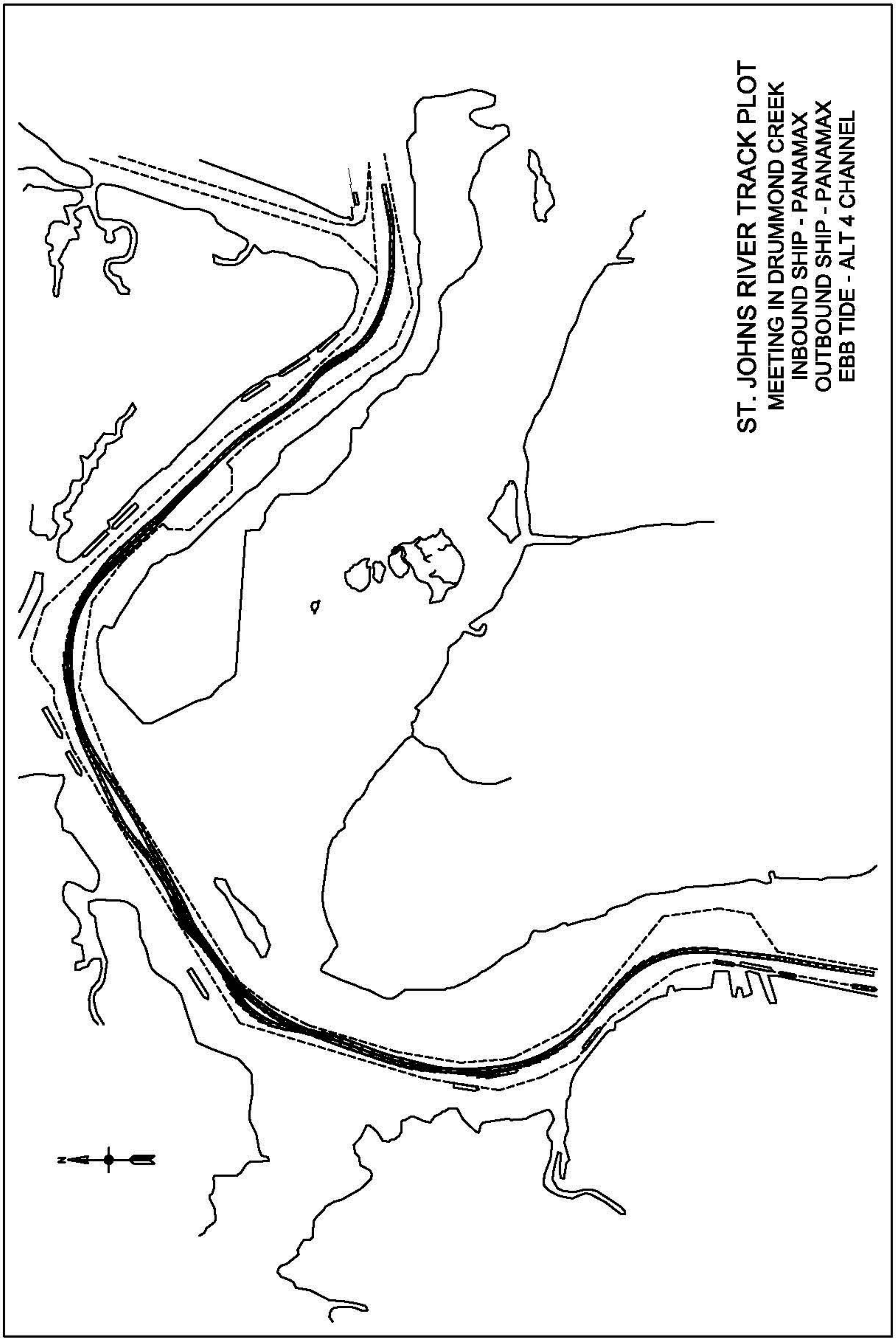

ST. JOHNS RIVER TRACK PLOT
MEETING IN DRUMMOND CREEK
INBOUND SHIP - PANAMAX
OUTBOUND SHIP - PANAMAX
EBB TIDE - ALT 4 CHANNEL

PLATE 14

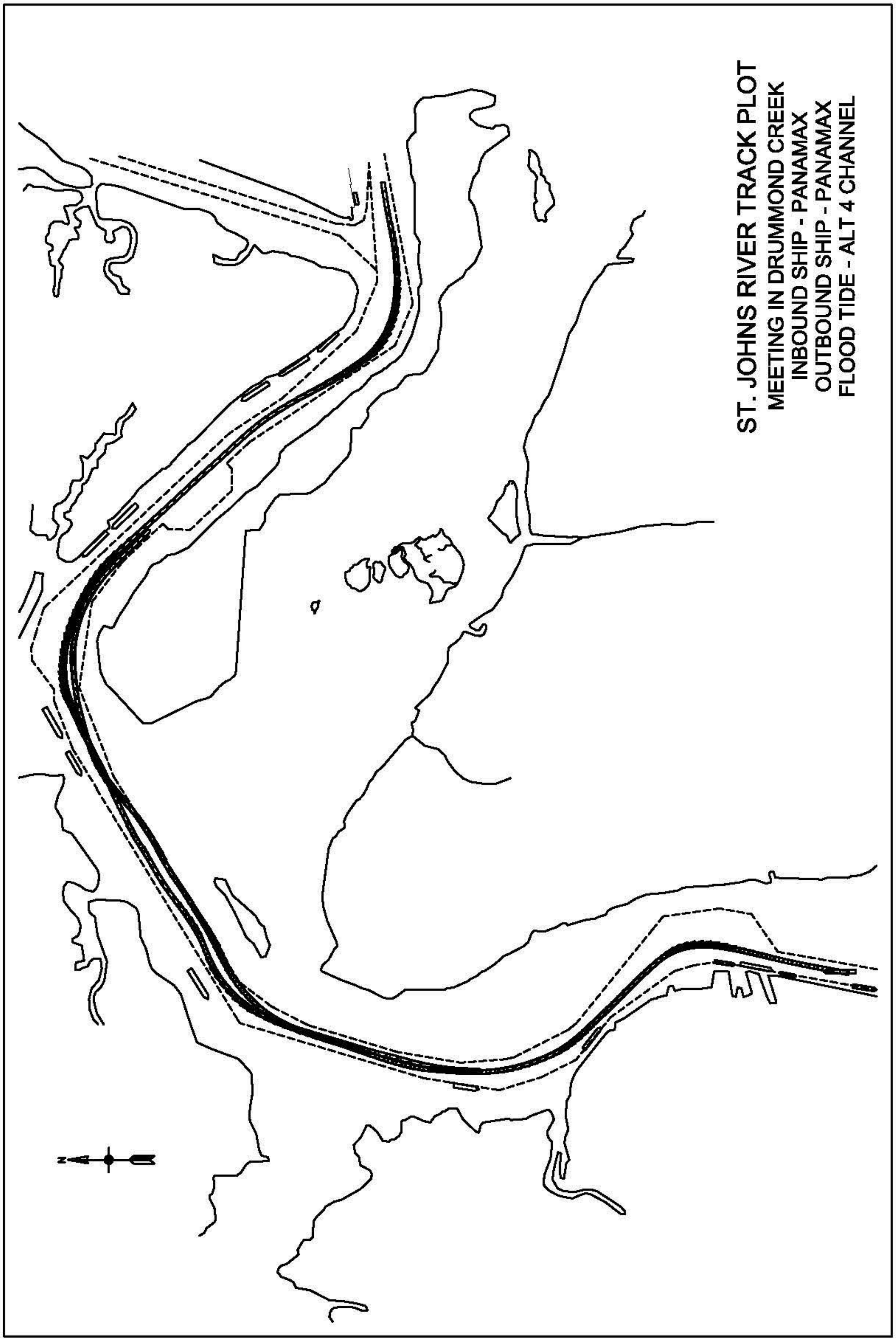

ST. JOHNS RIVER TRACK PLOT
MEETING IN DRUMMOND CREEK
INBOUND SHIP - PANAMAX
OUTBOUND SHIP - PANAMAX
FLOOD TIDE - ALT 4 CHANNEL

PLATE 15

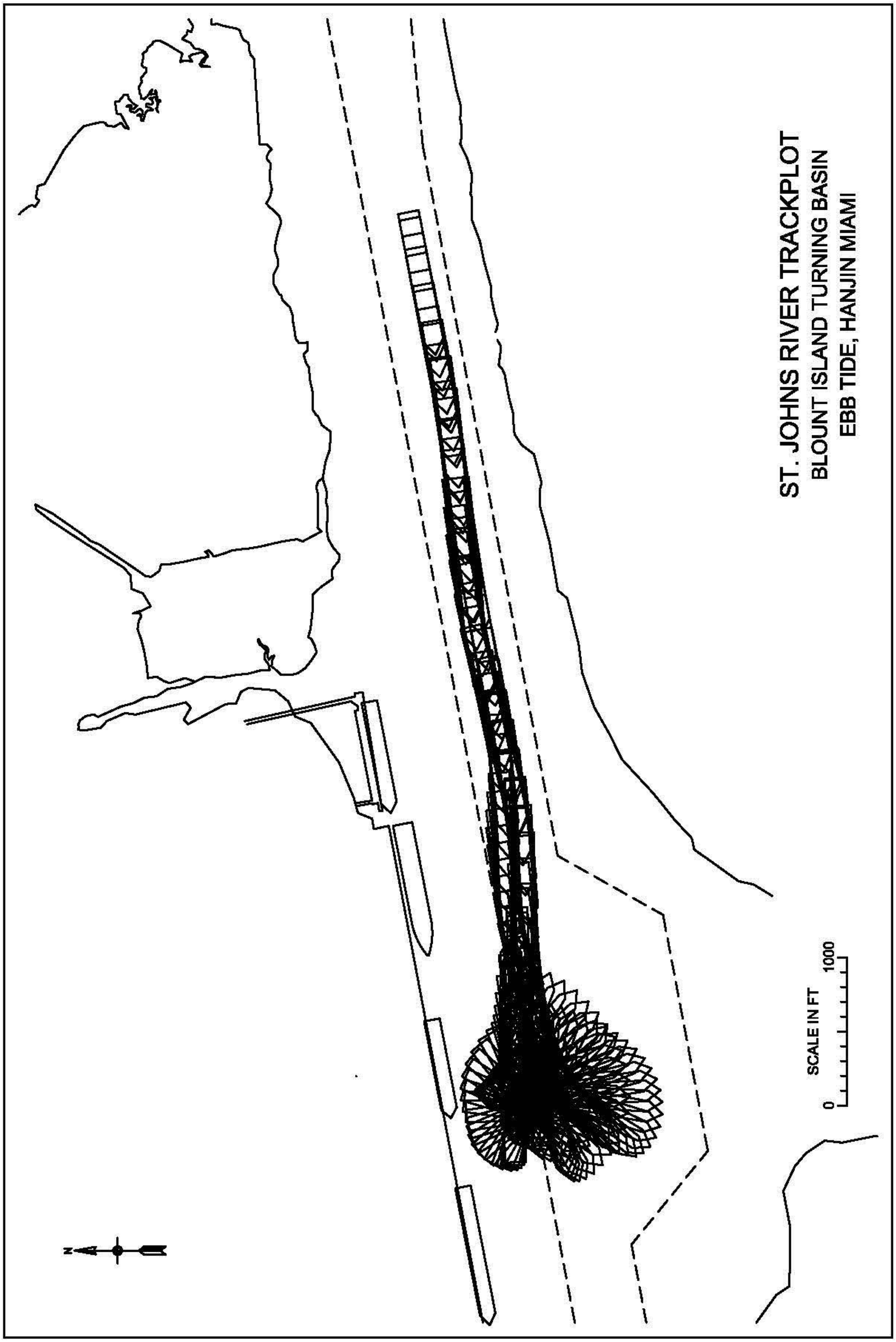

ST. JOHNS RIVER TRACKPLOT
BLOUNT ISLAND TURNING BASIN
EBB TIDE, HANJIN MIAMI
SCALE IN FT
0
1000
N

PLATE 16

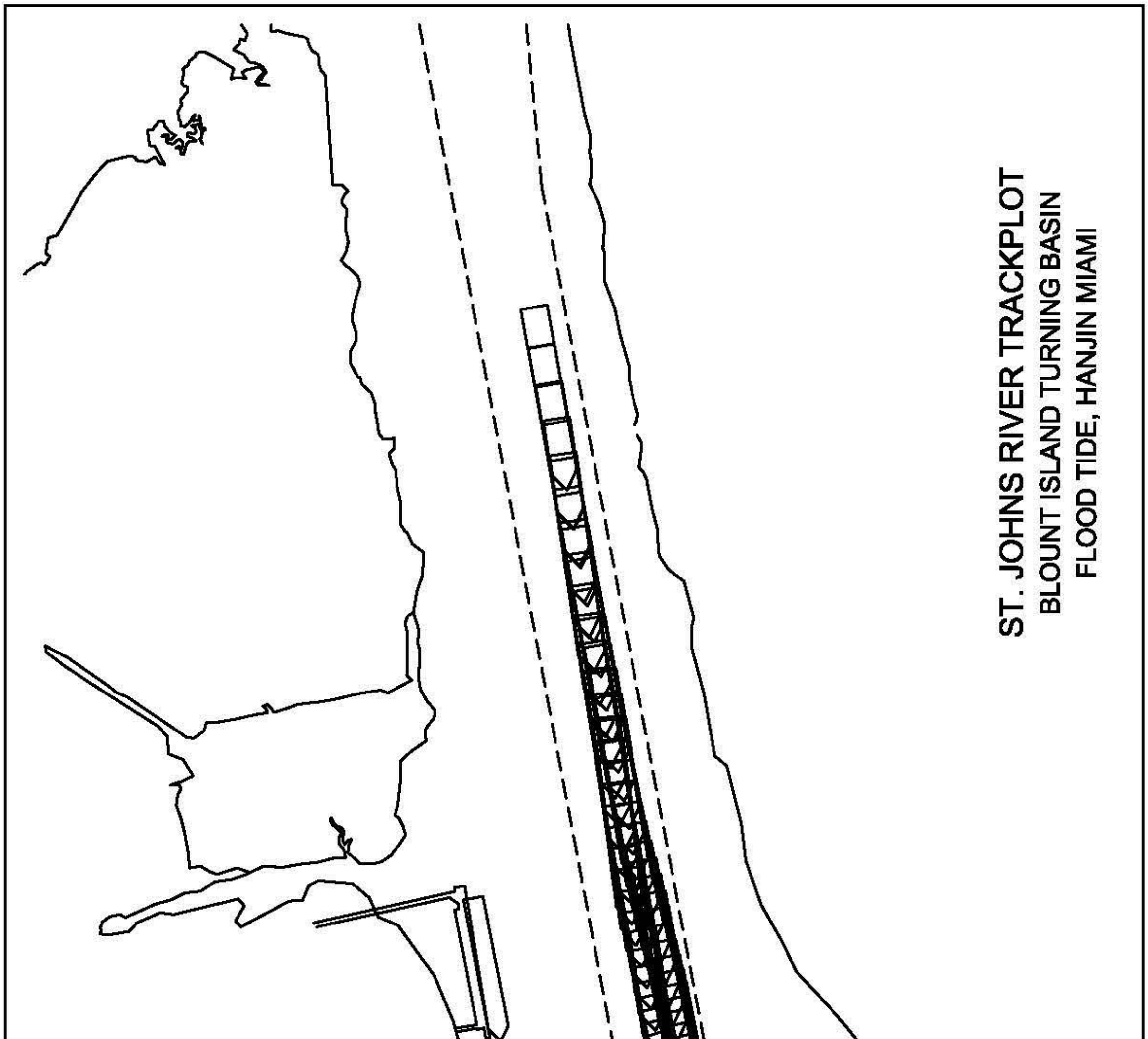

ST. JOHNS RIVER TRACKPLOT
BLOUNT ISLAND TURNING BASIN
FLOOD TIDE, HANJIN MIAMI
SCALE IN FT
0
1000
N

PLATE 17

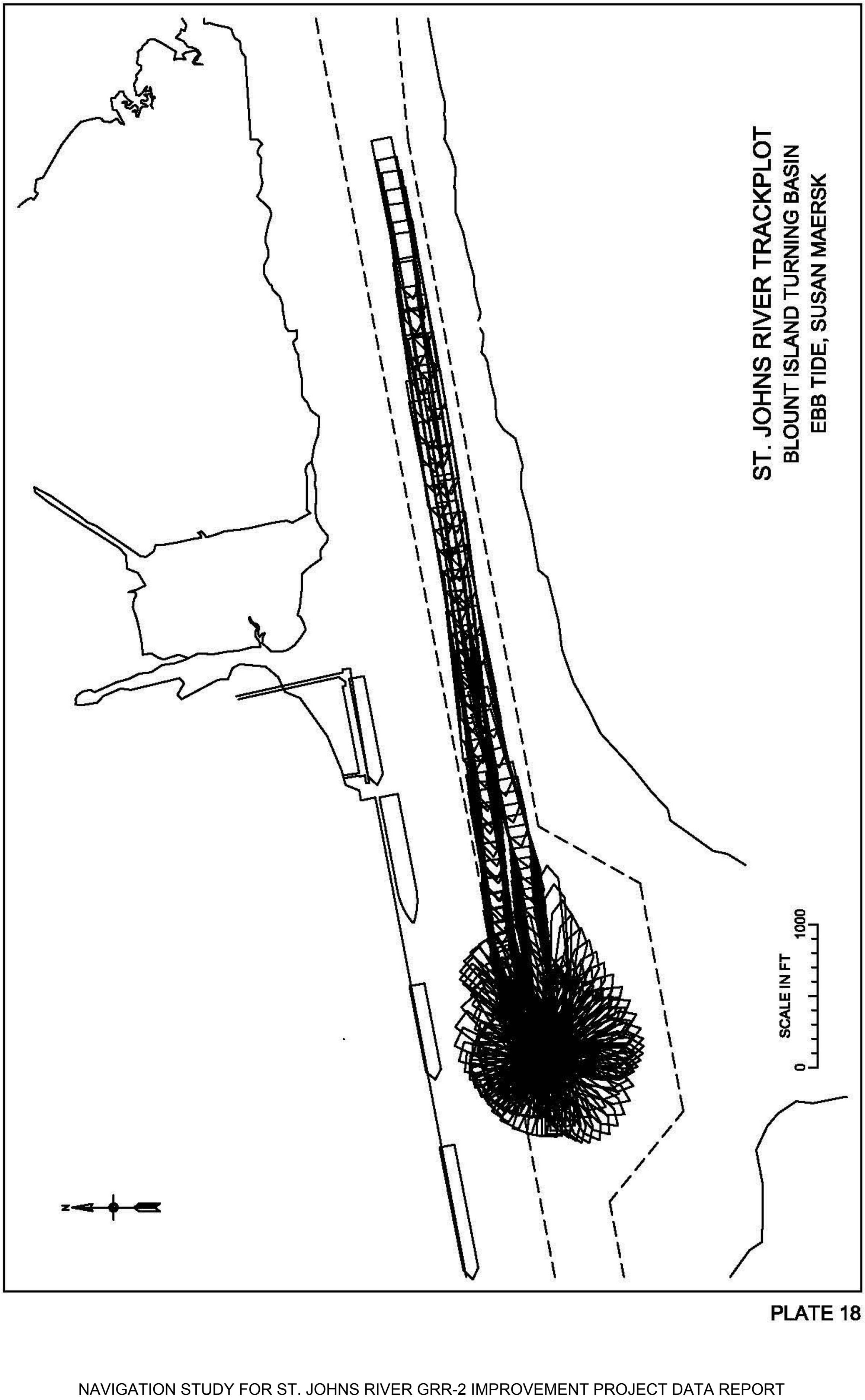

ST. JOHNS RIVER TRACKPLOT
BLOUNT ISLAND TURNING BASIN
EBB TIDE, SUSAN MAERSK
SCALE IN FT
0
1000
N

PLATE 18

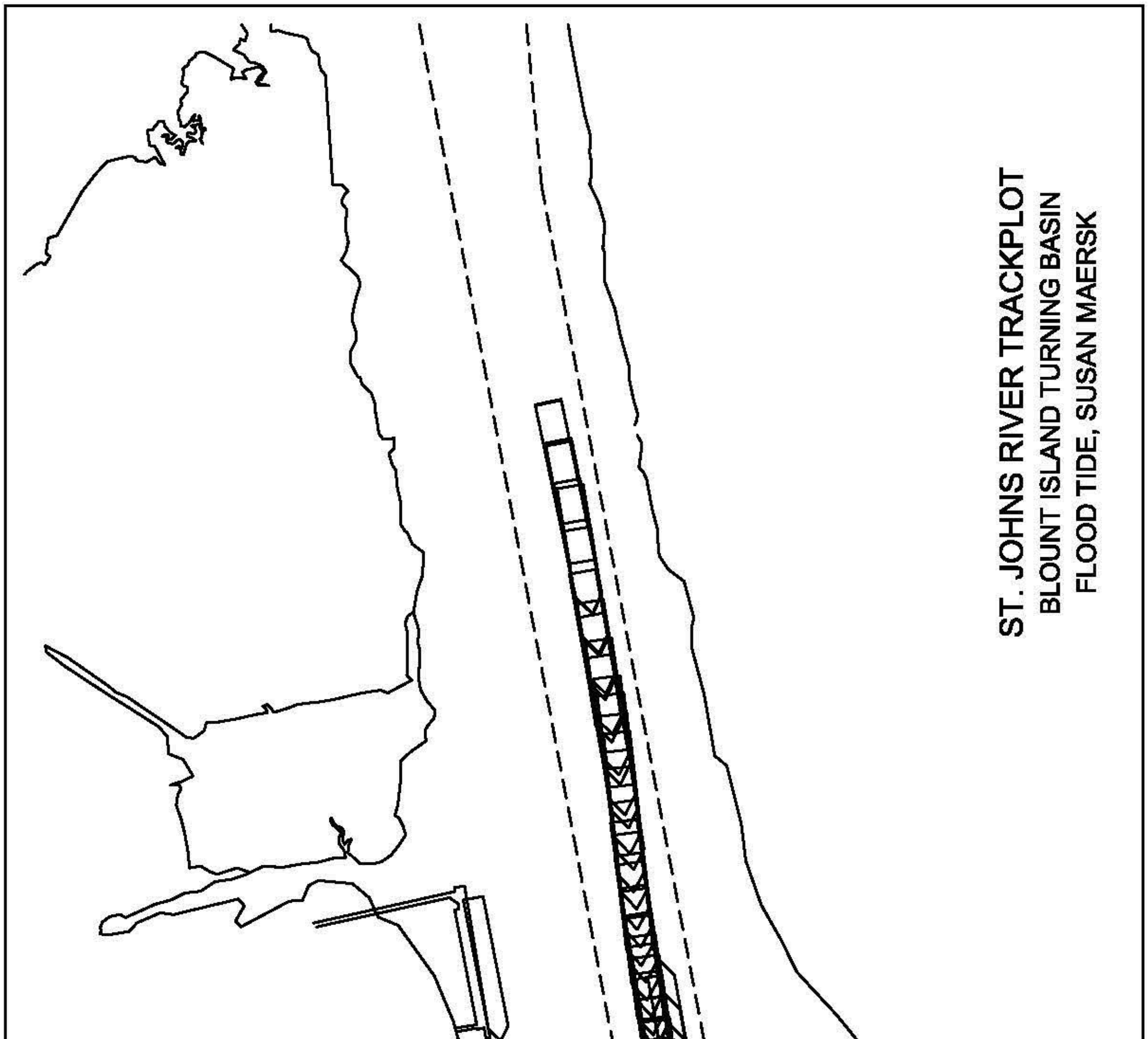

ST. JOHNS RIVER TRACKPLOT
BLOUNT ISLAND TURNING BASIN
FLOOD TIDE, SUSAN MAERSK
SCALE IN FT
0
1000
N

PLATE 19

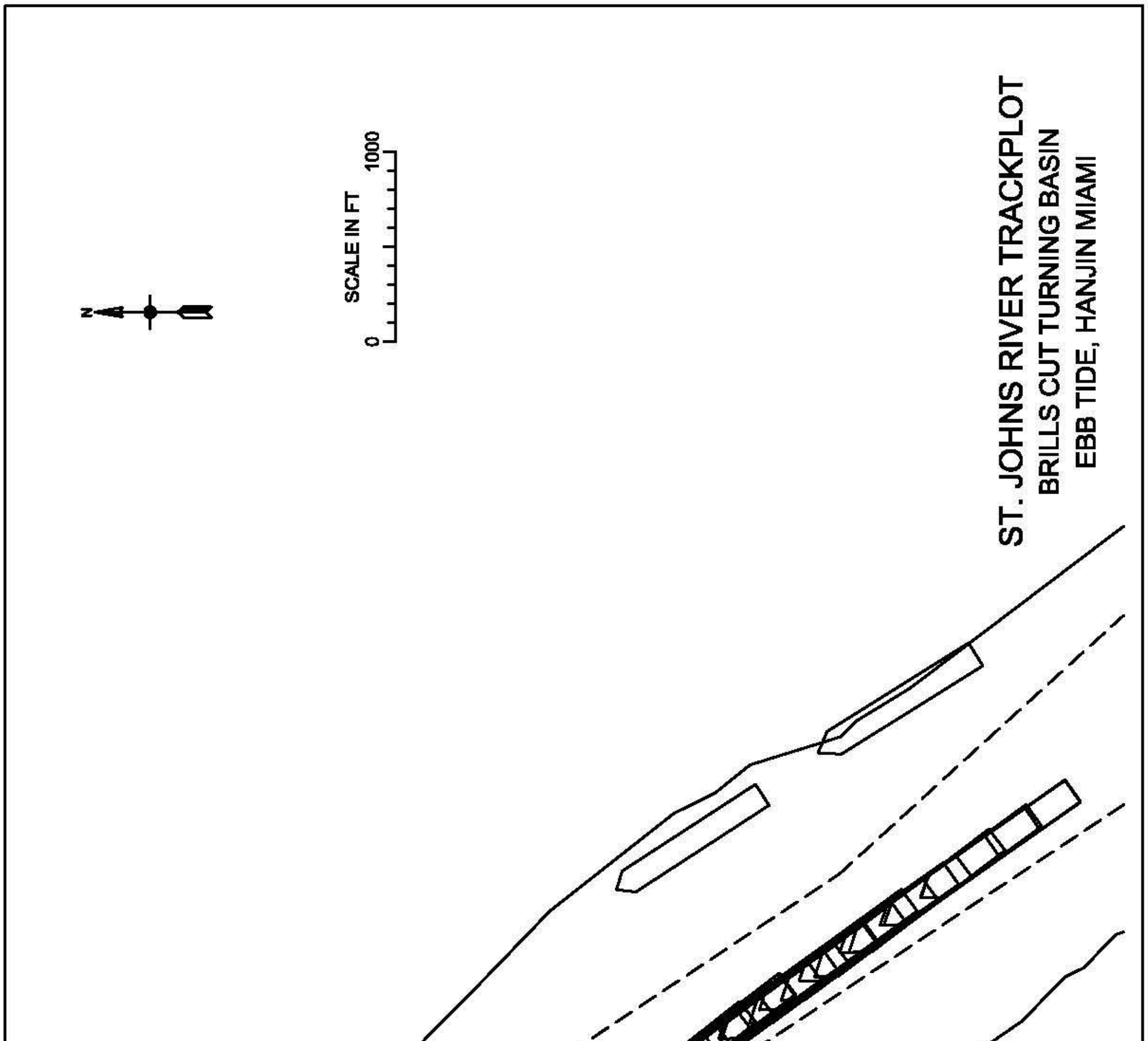

ST. JOHNS RIVER TRACKPLOT
BRILLS CUT TURNING BASIN
EBB TIDE, HANJIN MIAMI
SCALE IN FT
0
1000
N

PLATE 20

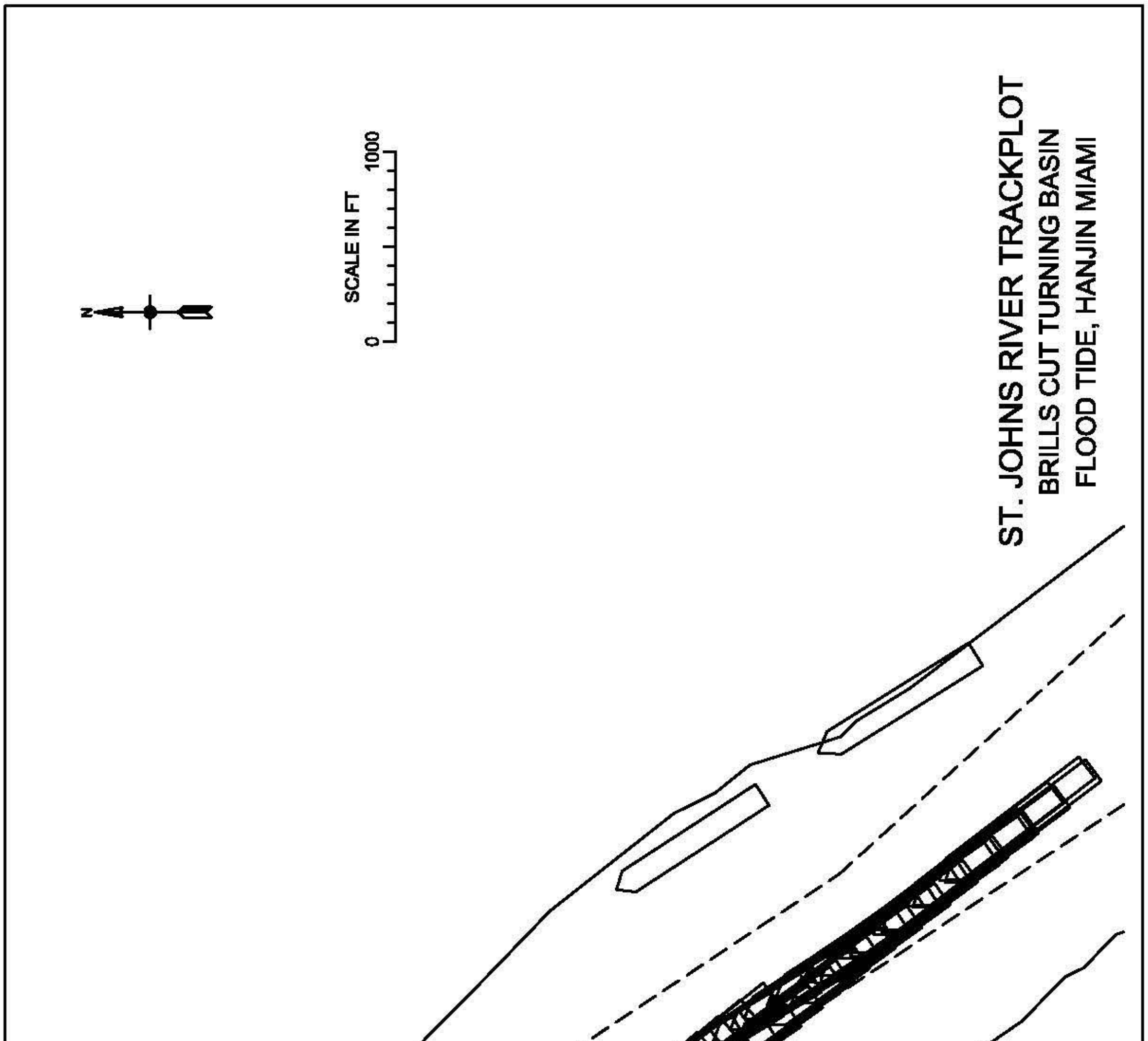
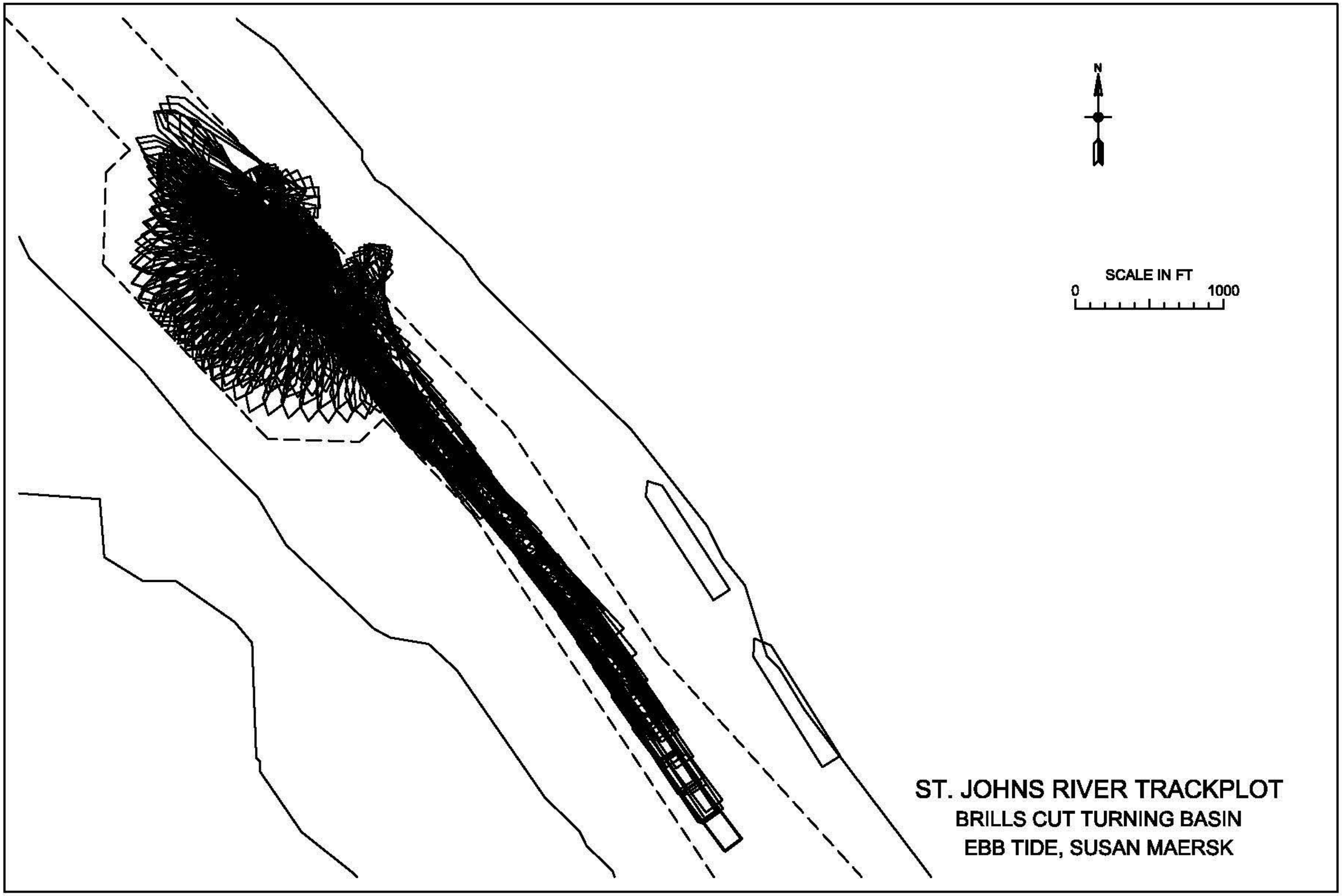
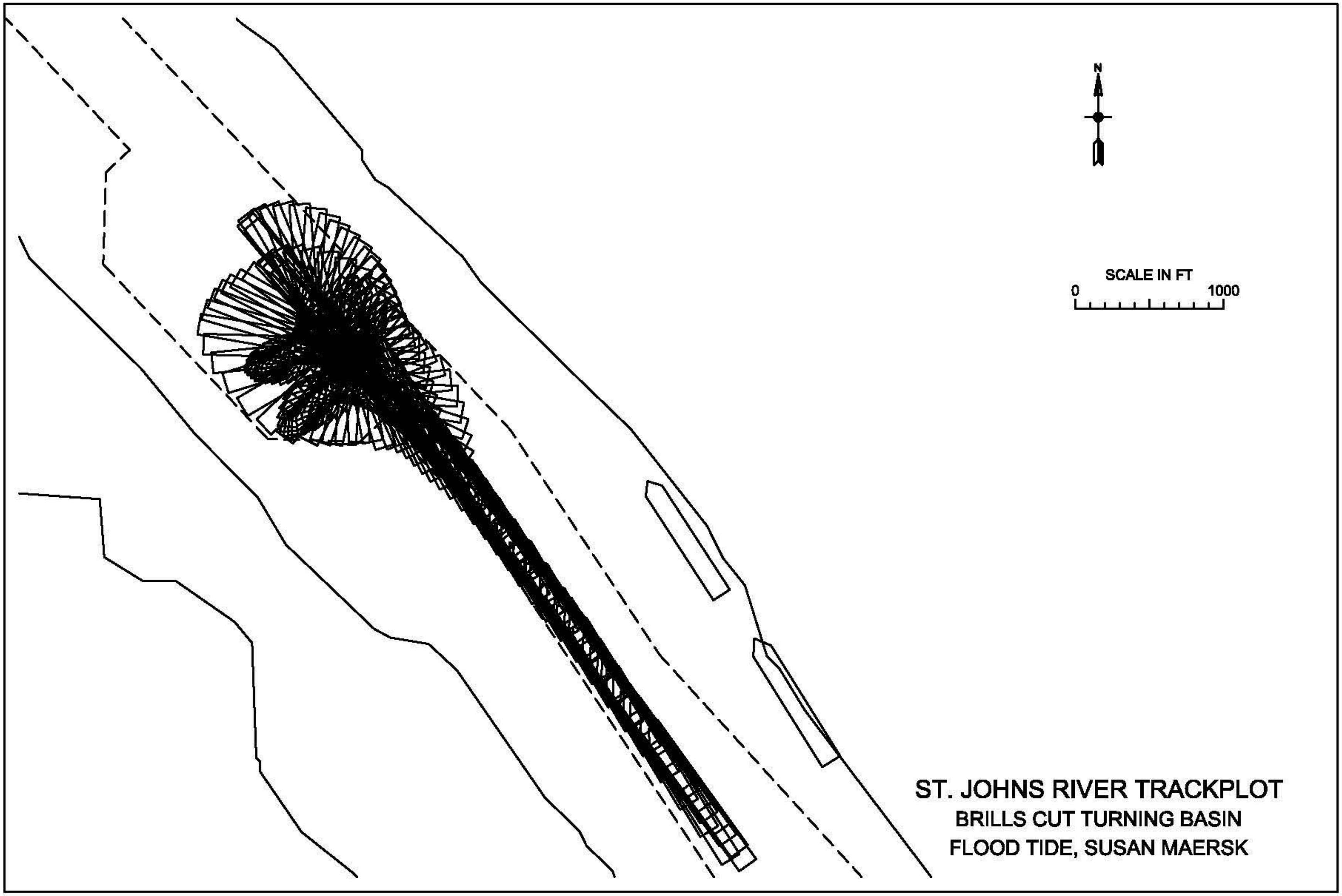

ST. JOHNS RIVER TRACKPLOT
BRILLS CUT TURNING BASIN
FLOOD TIDE, HANJIN MIAMI
SCALE IN FT
0
1000
N

PLATE 21

PLATE 22



ST. JOHNS RIVER TRACKPLOT
BRILLS CUT TURNING BASIN
EBB TIDE, SUSAN MAERSK


N
SCALE IN FT
0
1000
ST. JOHNS RIVER TRACKPLOT
BRILLS CUT TURNING BASIN
FLOOD TIDE, SUSAN MAERSK

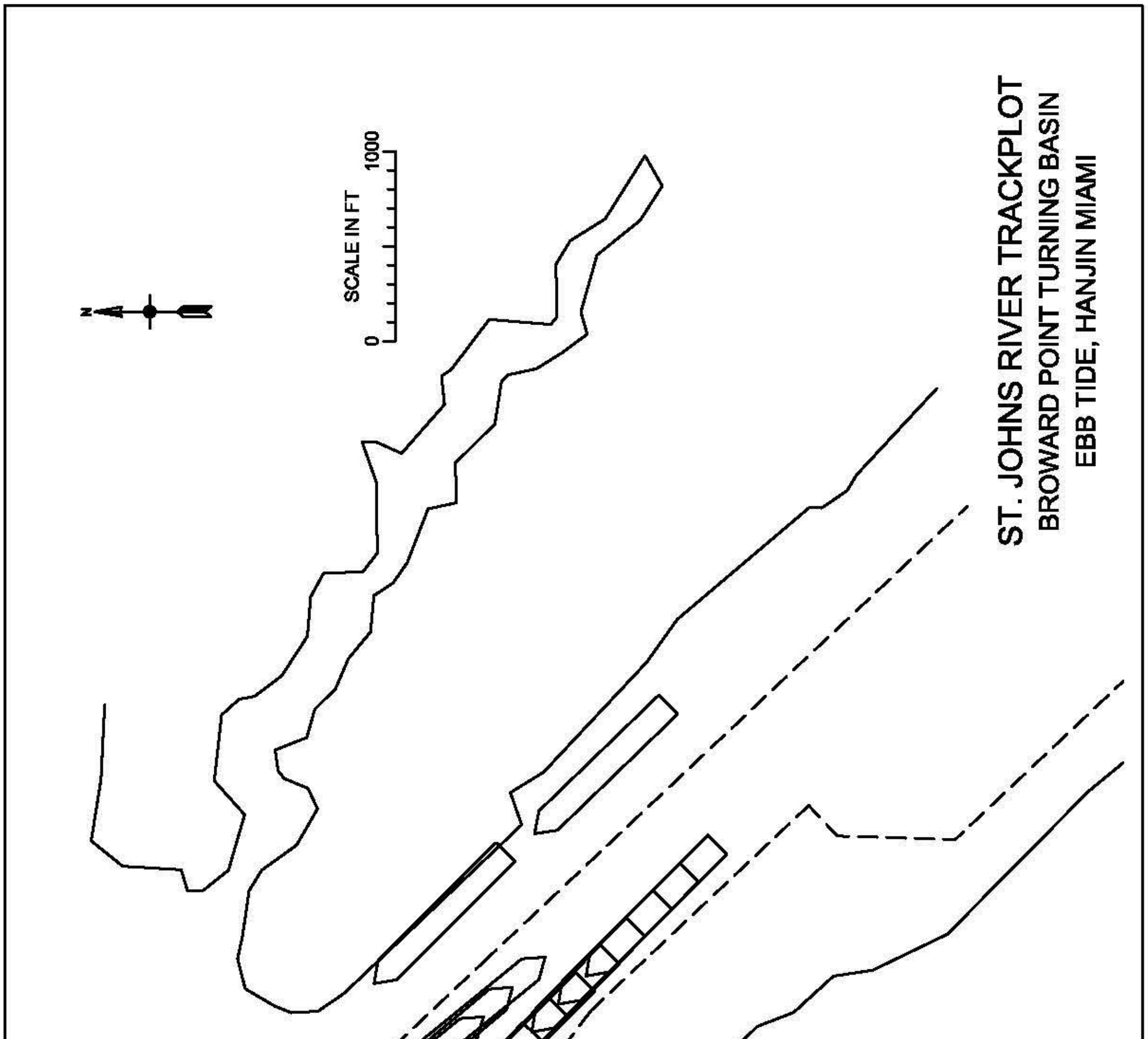

ST. JOHNS RIVER TRACKPLOT
BROWARD POINT TURNING BASIN
EBB TIDE, HANJIN MIAMI
SCALE IN FT
0
1000
N

PLATE 24

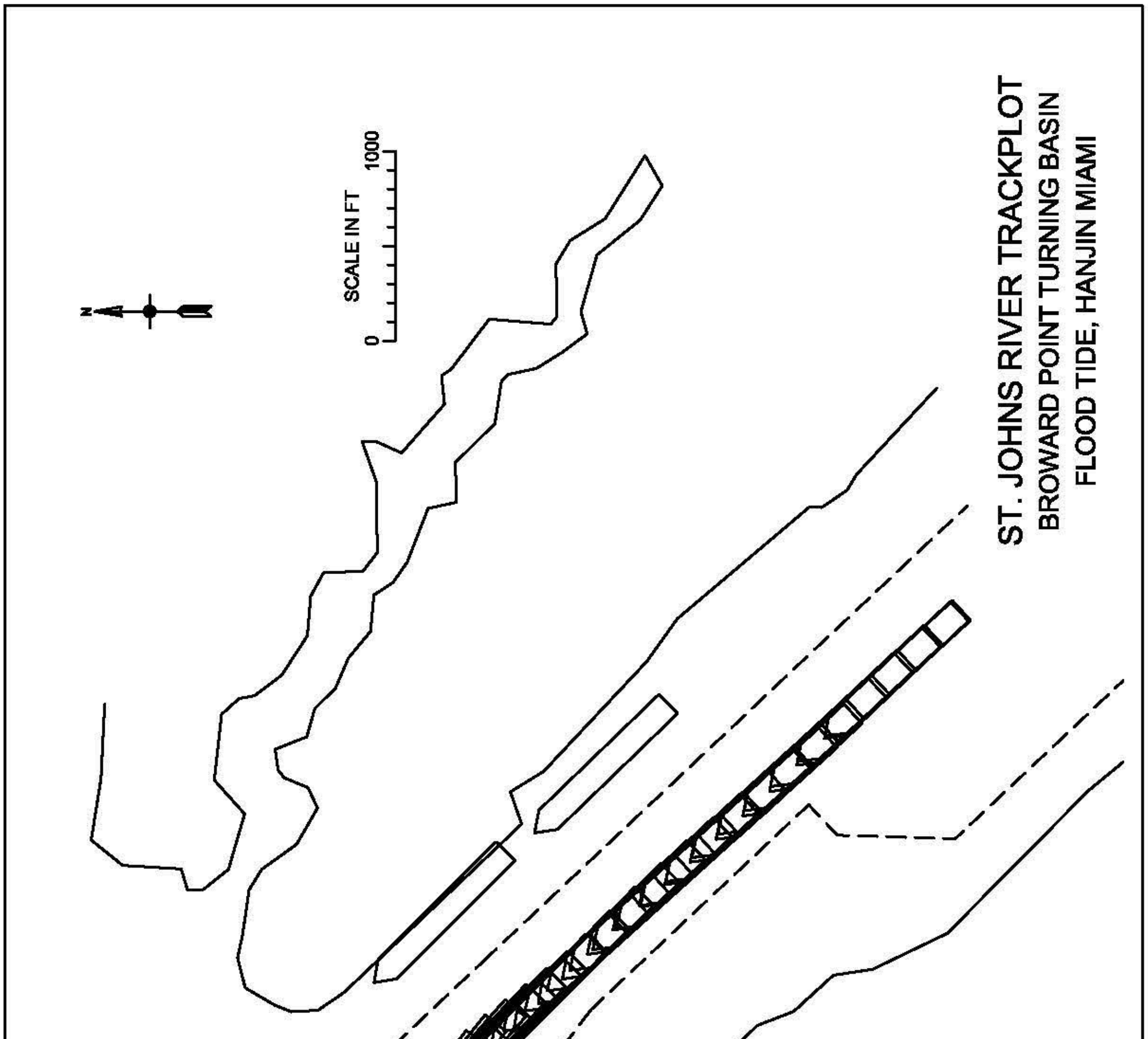

ST. JOHNS RIVER TRACKPLOT
BROWARD POINT TURNING BASIN
FLOOD TIDE, HANJIN MIAMI
SCALE IN FT
0
1000
N

PLATE 25

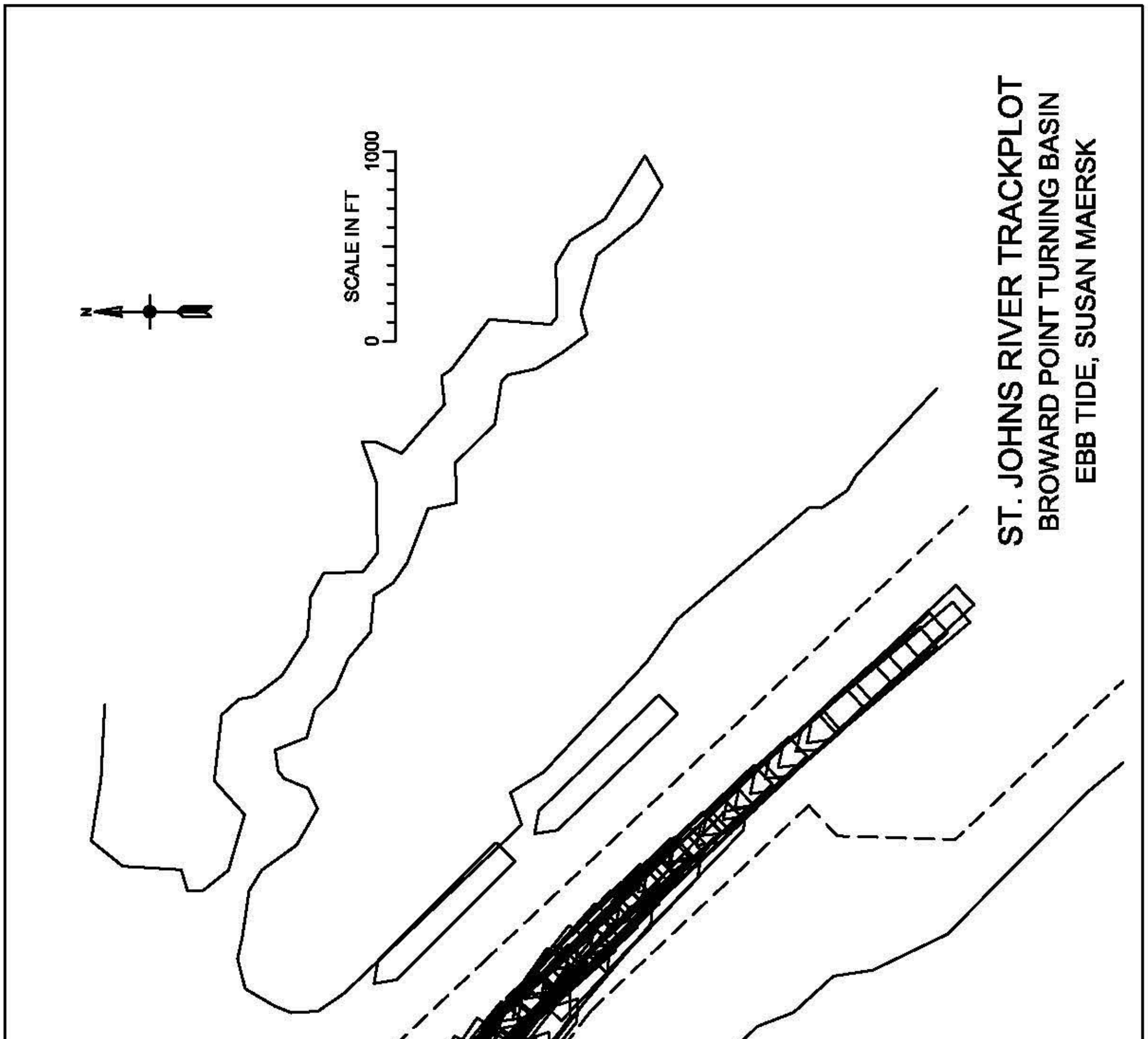

ST. JOHNS RIVER TRACKPLOT
BROWARD POINT TURNING BASIN
EBB TIDE, SUSAN MAERSK
SCALE IN FT
0
1000
N

PLATE 26

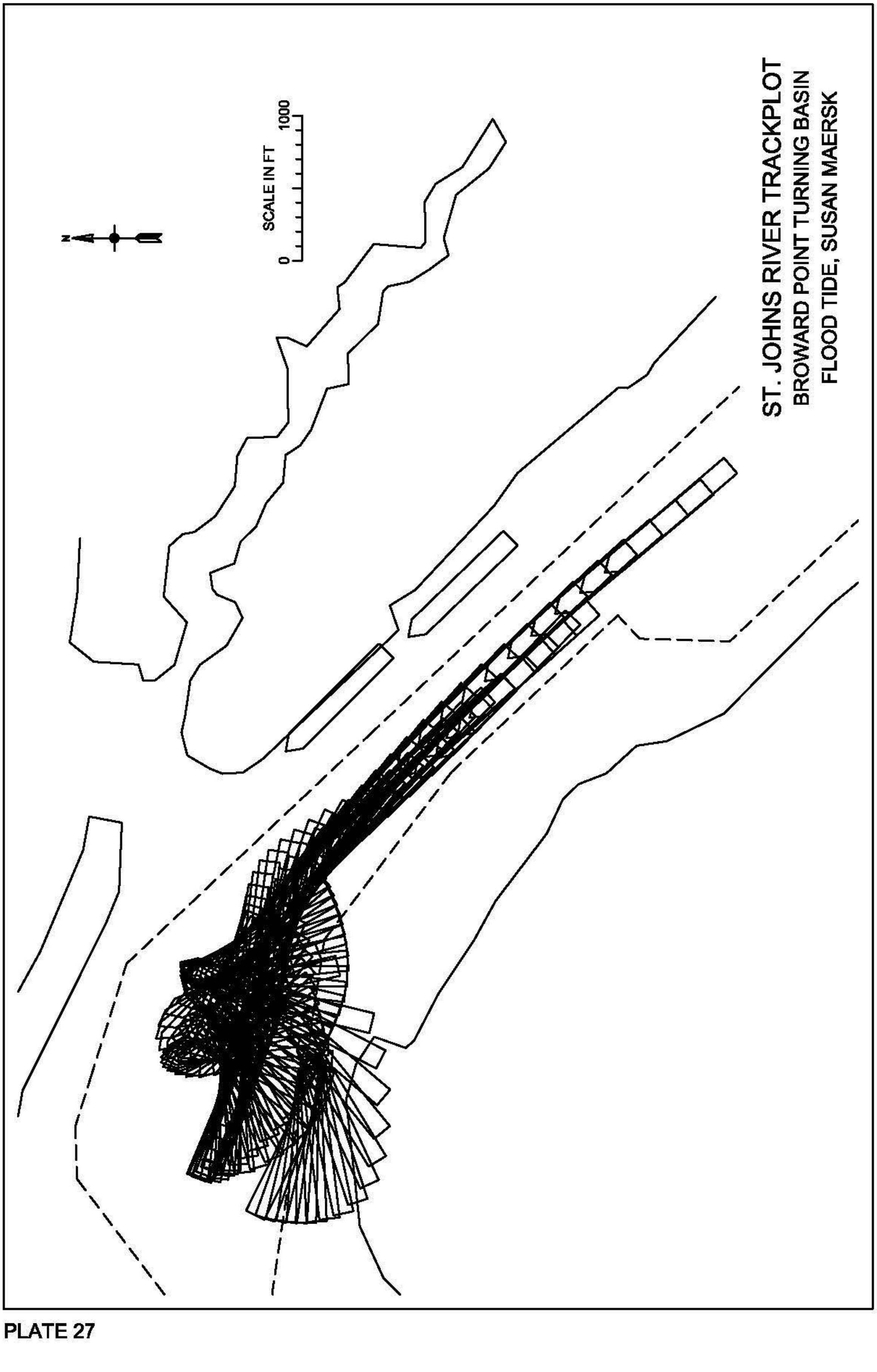

ST. JOHNS RIVER TRACKPLOT
BROWARD POINT TURNING BASIN
FLOOD TIDE, SUSAN MAERSK
SCALE IN FT
0
1000
N

PLATE 27

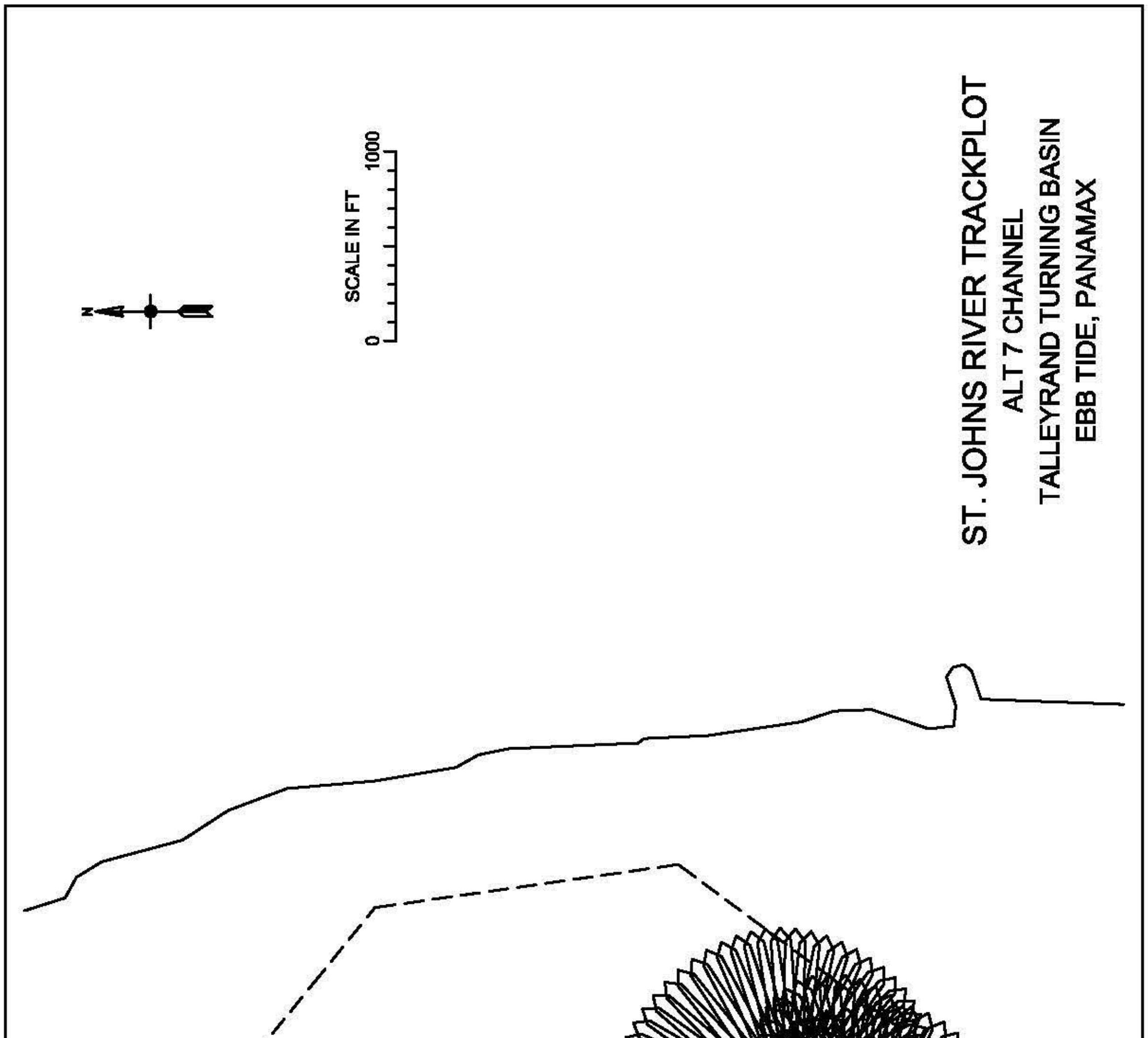
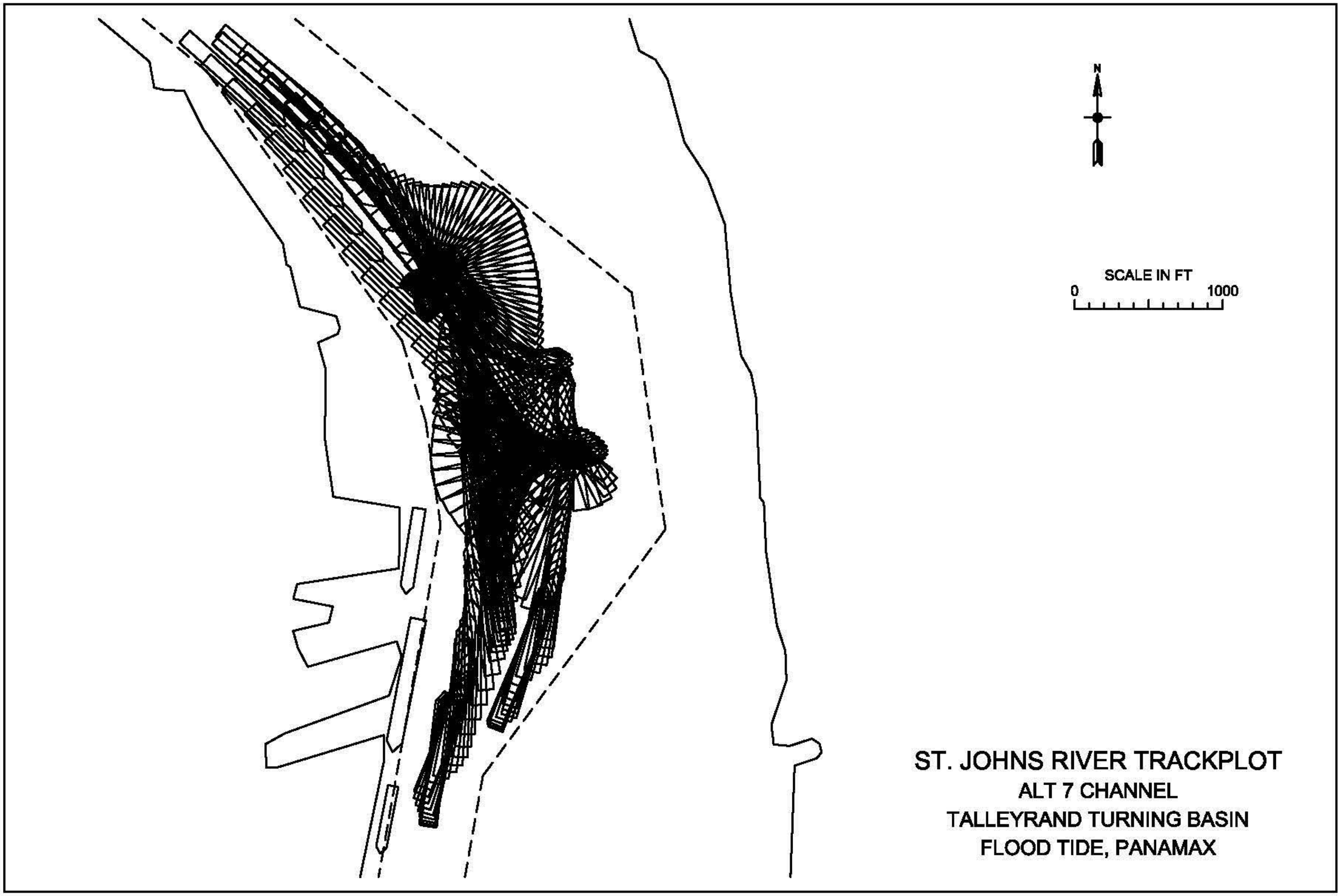

ST. JOHNS RIVER TRACKPLOT
ALT 7 CHANNEL
TALLEYRAND TURNING BASIN
EBB TIDE, PANAMAX
SCALE IN FT
0
1000
N

PLATE 28

PLATE 29


N
SCALE IN FT
0
1000
ST. JOHNS RIVER TRACKPLOT
ALT 7 CHANNEL
TALLEYRAND TURNING BASIN
FLOOD TIDE, PANAMAX

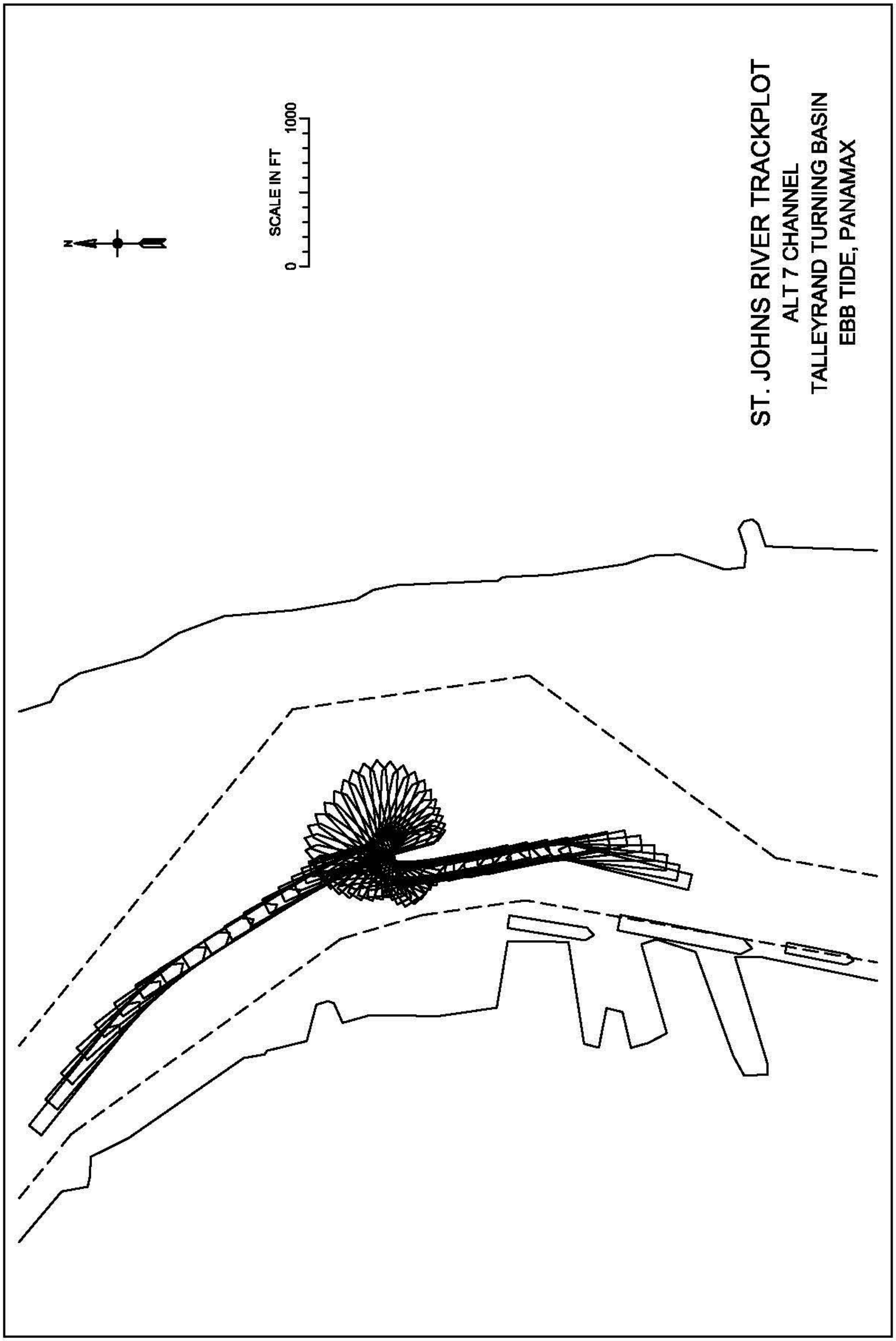
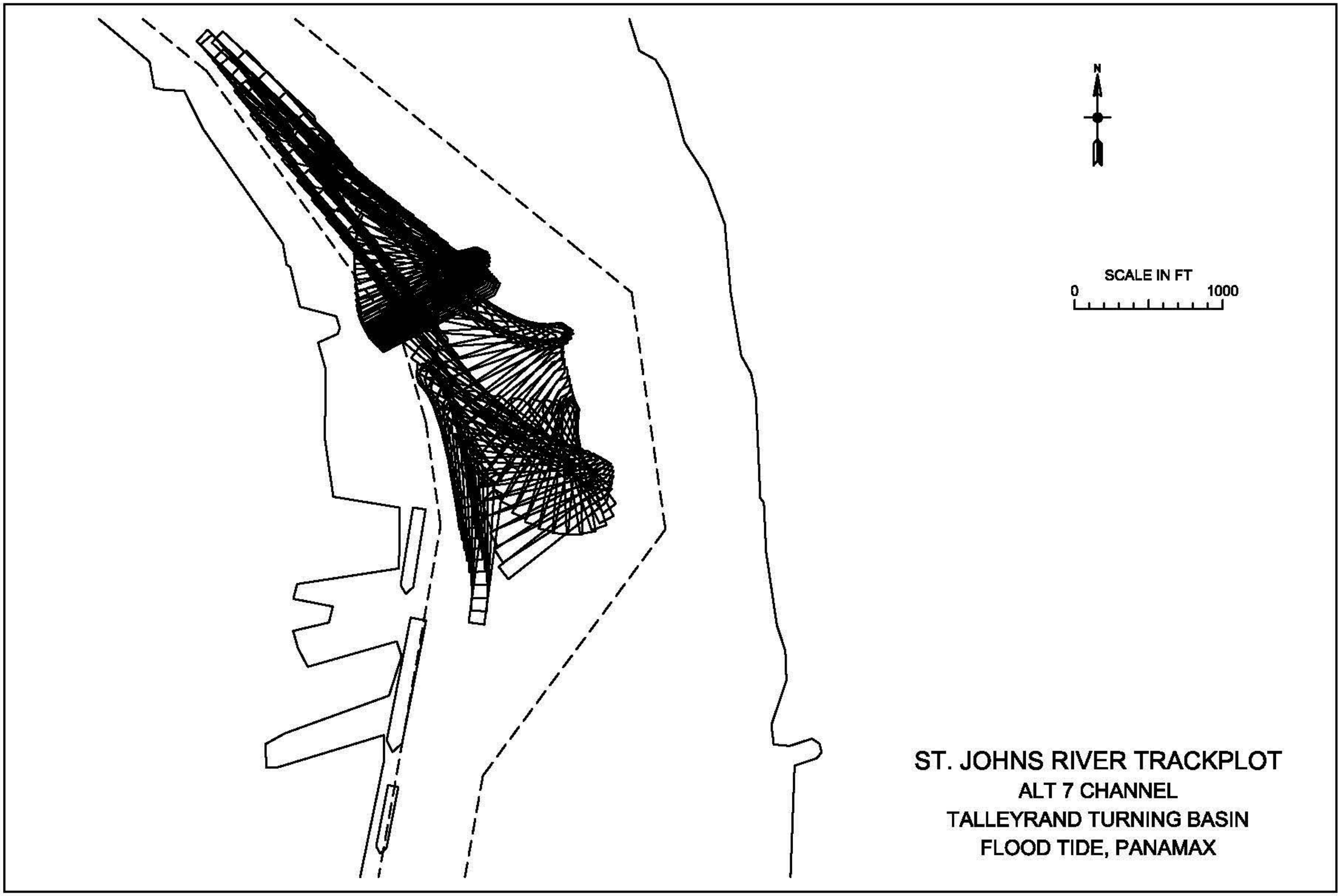

ST. JOHNS RIVER TRACKPLOT
ALT 7 CHANNEL
TALLEYRAND TURNING BASIN
EBB TIDE, PANAMAX
SCALE IN FT
0
1000
N

PLATE 30

PLATE 31


N
SCALE IN FT
0
1000
ST. JOHNS RIVER TRACKPLOT
ALT 7 CHANNEL
TALLEYRAND TURNING BASIN
FLOOD TIDE, PANAMAX

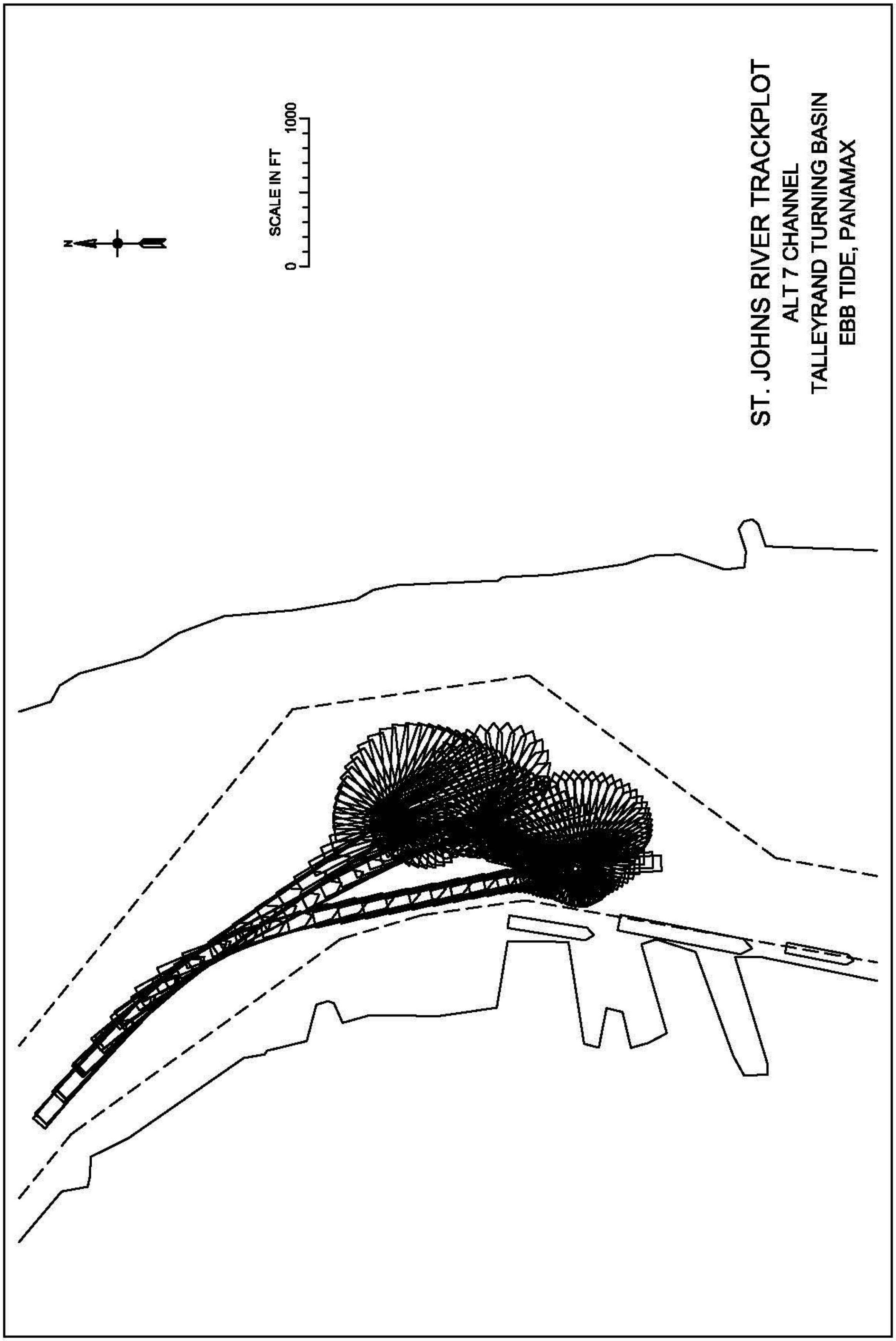
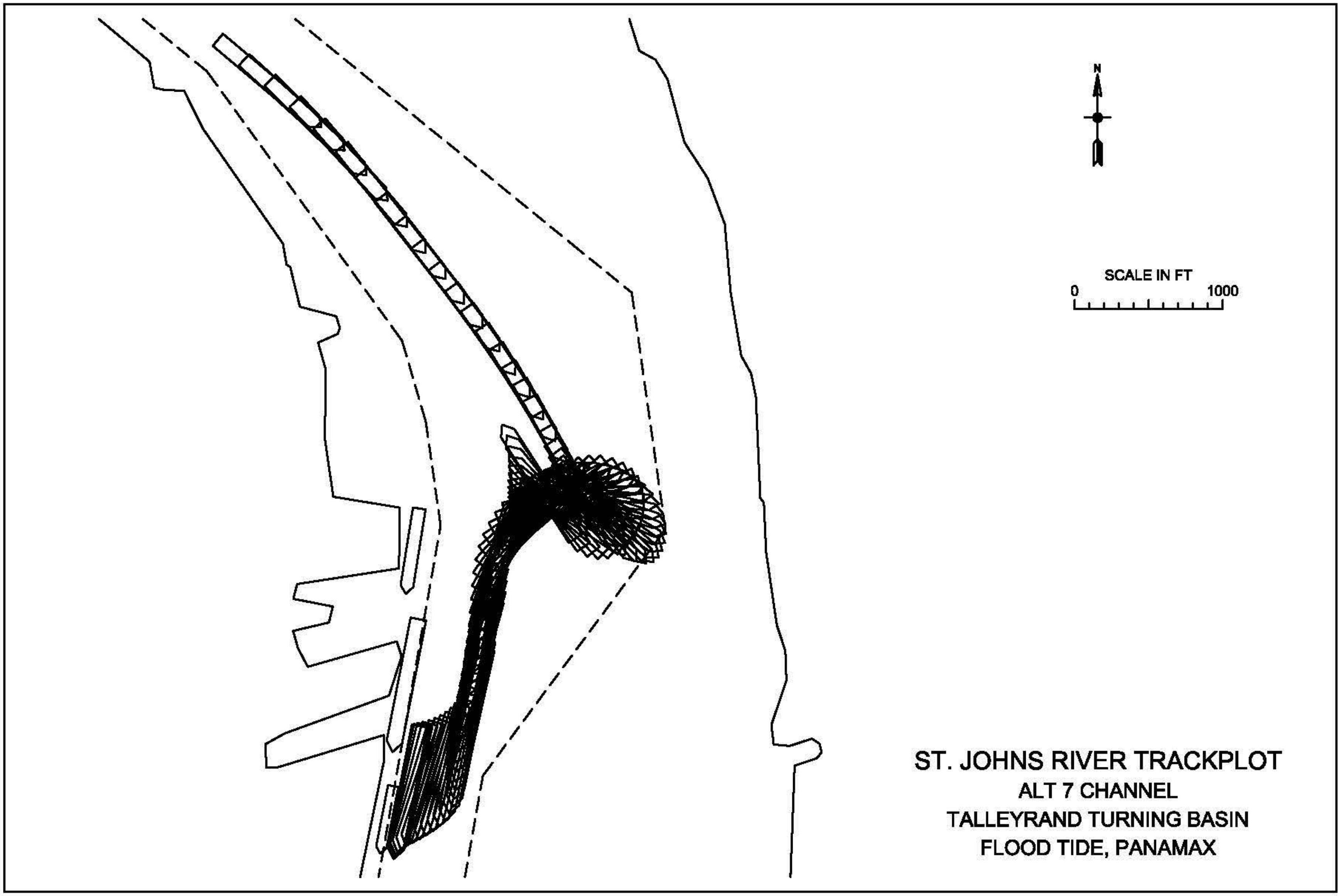

ST. JOHNS RIVER TRACKPLOT
ALT 7 CHANNEL
TALLEYRAND TURNING BASIN
EBB TIDE, PANAMAX
SCALE IN FT
0
1000
N

PLATE 32



ST. JOHNS RIVER TRACKPLOT
ALT 7 CHANNEL
TALLEYRAND TURNING BASIN
FLOOD TIDE, PANAMAX

NAVIGATION STUDY FOR

JACKSONVILLE HARBOR, FLORIDA

DRAFT INTEGRATED GENERAL REEVALUATION REPORT II

AND

SUPPLEMENTAL ENVIRONMENTAL IMPACT STATEMENT

APPENDIX A

ATTACHMENT J

Hydrodynamic Modeling for Storm Surge and Sea Level Change

TO BE INCLUDED.